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1877.

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JANUARY 1st, 1877.

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Cornelius, R., M'f'r, 821 Cherry st 1st & L
Cornelius, R. C., Manufacturer, 821 Cherry st
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Craig, Temple L
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Cramp, H. W., Clerk, 1700 Park ave C
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Cramp, Sam'l H., Ship Builder, Beach & Norris sts 1st
Cramp, Theodore, Ship Builder, Beach & Norris sts 1st
Cramp, W., Ship Builder, Beach and Norris sts 1st & L
Cramp, Wm. M., Ship Builder, Beach & Norris sts 1st
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Crosby, A L, Machinist, 22d ab. Arch st C
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Dallett, Thos H, Soaps, 951 Ridge ave 2d
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Davis, H C, Penn Mines, Mich C
Davis, Samuel H, Manufacturer, Leopard and Otter sts C
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Dawson, Wm, Carpenter, 515 N 10th st C
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Deitrich, Emile F L
Deitz, W H, Plumber, 312 Dickinson st C
Delbert, Simon, Tallow, 1724 Arch st L
Denis, G P, Manufacturer, Phila
Dennison, Wm, C.E., 1705 Page st C

Derbyshire, A J, 109 N Water st C
Desmond, Wm C, Costumer, 917 Race st C
Deutz, A, Cornelius, Jeweler L
Devlin, Thos, Iron Foundry, 9th and Jefferson sts C
Dewees, W W, Machinery C
Dexter, Chas L, Confectioner, 245 S 15th st C
Dialogue, John H, Steam Ship Builder, Broadway and Pine st, Camden, N.J. 2d.
Dick, Evan R 1st
Dick, Franklin 1st
Dickens, Elias, Machinist, 110 Spruce st C
Dickerman, Chas F, Boots and Shoes, 1120 Wallace st C
Dietrichs, E F, 422 Ludlow st L
Dietrick, D P, Merchant, 308 Chestnut st C
Dillon, Eli, Plasterer, Ridge ave & Green st L
Disston, Albert H, Saw M'f'r, 1326 N 15th st 2d
Disston, Thos S, Saw Maker, Tacony, Pa 2d
Dixon, E S, Lawyer, 715 Walnut st 2d
Dixon, G B, Furnaces and Ranges, 1324 Chestnut st 2d
Dixon, G W, Insurance, 108 S 4th st 2d
Doerr, Charles A, Sash M'f'r, 38th and Spring Garden sts C
Doll, George, Turner, 10 N 6th st C
Donohugh, Wm J, Clerk, 723 Arch st C
Donovan, Daniel, 608 Market st 2d
Dotterer, Amos, Brick M'f'r, 1319 S Broad st C
Dougherty, Jas, Moulder, 13th and Buttonwood sts L
Dougherty, William, Engraver, 2 Swarthmore Place 2d
Dougherty, W H, Distiller, 1435 Girard av C
Douglas, E V, Machinist, Germantown C
Dowler, Jacob, Coal Dealer, 645 N 11th st C
Downing, Rich'd H, Iron, 1613 Race st L
Doyle, James, Builder, 911 Filbert st C
Draper, Edmund, Math. Inst. Maker, 226 Pear st L
Draper, Prof., John W. L
Drayton, Wm. Heyward, Lawyer, 704 Walnut st L
Dreer, Ferdinand J., 1520 Spruce st. L.
Drown, Wm. A., Umbrellas, 246 Market st C
Drown, Jr., W. A., Umbrellas, 246 Market st C
Drysdale, T. M., Physician, 1531 Arch st C
Du Bois, H. M., Manuf'r, 919 N. 13th st C
Du Bois, Wm. E, Assayer, U. S. Mint C
Dubois, W. L., Treasurer, 421 Chestnut st C
Dubree, Henry, Car Builder, 3625 Walnut st C
Ducomb, John F., Book Binder, 27 S. 6th st L
Dudley, C. B., Chemist, Altoona, Pa C
Dudley, P. H., C. E., 27 West 9th st., N. Y. C
Dulles, Joseph H., Merchant L
Dulles, Perit, Broker, 4037 Chestnut st 2d
Dundore, Franklin, 519 N. 6th st 1st
Dundore, Nathan, 220 S. 4th st 1st
Dunglison, T. R., Physician, 814 N. 16th st C
Du Pont, Irene, Manuf'r, 37 S. Front st C
Dunwoody, Chas., Merchant, 3266 Sansom st C
Dupuy, Chas. M., C. E., 4102 Spruce st C
Durang, Edwin F., Architect, 51 N. 6th st C
Durfee, W. F., Engineer, 1211 Green st C
Dwight, E. P., Hyd. Engineer, Evelina & Levant sts 2d
Dye, John H., Surveyor, 224 S. 5th st 2d
Dykeman, Geo R., 43d & Oregon sts 1st

Eadline, G. W., Bustleton, 23d Ward 2d
Eakin, Constant M. L
Eastburn, Geo., Teacher, 112-114 N. 9th st C
Eastwick, A. M., Machinist, 121 Walnut st L
Eavenson, A. T., M'f'r, 2013 Vine st C
Eccles, J., Machinist, 2423 Lombard st 2d
Edmunds, Henry R., Attorney at Law, 619 S. 10th st C
Ehlers, P., Engineer, 101 S. Front st C
Eldridge, G. M., Lawyer, 708 Walnut st 2d
Elkinton, G. M., Tallow, 424 N. 4th st L
Elkinton, H. H., Engineer, 477 N. 4th st C
Elkinton, Jos. S., Manuf'r, 331 S 5th st L
Elliott, James, 39 N. 7th st C
Ellis, Wm. H., Carpenter L
Eltonhead, W. B., Jeweler, 122 S. 2d st C
Elverson, J., Publisher, 8th & Locust sts C
Elwell, John K., Salesman, 850 Marshall st C
Elwyn, Dr Alfred, 1422 Walnut st L
Emerick, John A., Foundry, 163 Allen st 2d
Emery, Abram D., M.E., 1911 Sepviva st C
Emery, T. S., Iron Manuf'r, 334 Walnut st C
Endicott, M. T., Civil Eng'r, Naval Station, New London, Ct C
Engard, Albert. C. Engineer, U. S. N., 2204 Mt. Vernon st C
Entrekin, W. G., Photographs, 4384 Main st., Manayunk C
English, J. E., Plasterer L
Ennis, Prof. J., Principal L
Eppelsheimer, A., Grocer, 10th & Sp. Gard'n C
Erben, P. C., 206 W. Logan Square C
Erety, W., Bookbinder, 288 N. 3d st L
Estlack, Chas. E., Bricklayer, 119 S. 18th st C
Estlack, George, Builder, 119 S. 18th st C
Estrada, R., Engineer, 1012 Passyunk av C
Eustis, W. L., C. E., 270 S. 3d st C
Evans, Chas., Machinist, 1011 Vine st L
Evans, C. A., Civil Engineer, 324 Benson st., Camden, N. J. C
Evans, Thos. R., Merchant, 28 S. 4th st C
Evans, W. W., Civil Engineer, 47 Ex. Place C
Everett, Wm., Engineer, Rye, N. Y. L
Ewing, G. C., Jr., Merchant, 715 Chestnut st C
Ewing, Daniel S., Merchant, 1127 Chestnut st C
Ewing, Wm. C., 715 Chestnut st 1st
Exley, Wm., Blacksmith, 319 Wood st C

Fagerstrom, A. W., Machinist, 1820 Hamilton st C
Fairbanks, C. H., Printer L
Fairbanks, E., Manuf'r, St. Johnsbury, Vt L
Fairthorne, R. F., Druggist, N. W. 19th & Arch sts 2d
Fahnestock, G. D., Clerk, 307 Walnut st C
Farr, Wm. M., 1912 Spruce st C
Faser, C., Frame Maker, 822 Arch st 2d
Faught, L. R., Superin'd't, 1220 N. 18th st 1st
Fell, J. G., Coal, 303 Walnut st 1st
Fell, John R., 1106 Walnut st 1st
Felt, A. B., Sewing Mach., 1223 Chestnut st C
Fennemore, G. H., Photogr'r, 820 Arch st C
Fenton, J. H., Manuf'r, 145 Race st C
Ferguson, J., Bookkeeper, 9 N. 11th st L
Ferguson, Jos. C., Engineer, 522 Walnut st 1st
Ferrel, Jos. L., Iron Manuf'y, 2218 Race st C
Fresquet, A. A., Chemist and Engineer, 323 Walnut st C

Fewkes, Jos. F., Light Mach'ist, 259 S. 24th st C
Field, Charles J., Hardware, 633 Market st C
File, John C., Merchant, 238 N. 3d st C
Finley, Thos., Carpet and Rope Maker, 23 N. Front st 2d
Firmstone, Wm., 303 Walnut st 1st
Fisher, Joseph L
Fisher, Thos. R., Manufacturer, Germantown L
Fisler, Jacob H., 1516 Swain st L
Fiss, G. W., Worsted Manufactory, 26 S. Front st C
Flanagan, James M., 420 S. Delaware av 1st
Flanagan, Stephen, 420 S. Delaware av 1st
Flanigen, C. Douglass, Mechanical Engineer, 2120 Spruce st C
Fleisher, Moyer, Watch Mkr., 25th & Biddle sts C
Fleming, Wm. A., Metal Refiner L
Fodell, Wm. P., Secretary, 58 Laurel st C
Foote, Chas. H., Machinist, 1122 Anita st C
Forsyth, Joseph W., Plumber, 619 Walnut st L
Foster, Chas. E., Clerk, 1233 Chestnut st L
Foster, Joshua, Teacher, N. W. Broad and Pine sts C
Fouche, Franklin H., Salesmen, 239 N. 6th st L
Fouche, W. W., Dentist, 239 N. 6th st 2d
Fowler, Chas. Ed., Machinist, 1204 Callowhill C
Fowler, John, Mechanical Engineer, 37 Laurel st C
Fox, Samuel L., Optician, 924 Chestnut st C
Fraiser, James, Carpenter, 331 Pine st C
Fraley, Frederick, President, 417 Walnut st 1st
Fraley, J. C., 2017 Delancey Place 1st
Frazer, Persifor L
Frazer, Persifor, Jr., Geologist, 1517 Walnut C
Frederick, Montgomery L., Engraver, 153 S. 4th st L
Freedley, Dr. Samuel, 549 Marshall st L
Freedley, W. G., Marble, 210 S. 24th st D
Freeman, Harold A., C. E., 12 West Penn sq C
French, Alonzo, M'f'r, 238 N. 9th st C
French, Louis H. 1st
Friez, Julien P., Electric Inst's, Baltimore, Md C
Fritz, Peter, Marble Mason, 616 Race st L
Frost, E. J., Manufacturer, 223½ S. 5th st C
Fry, Howard, Engineer, Williamsport, Pa C
Fry, Jacob W., 908 N. 5th st L
Fry, Paul Jones, Insurance Broker, 1734 Mt. Vernon st C
Fulforth, F. P., Clerk, 17 N. 7th st C
Fulton, Henry A., Clerk, 1600 Hamilton st 2d
Fulton, Mahlon, Wagon Builder, 2015 Spring Garden st C
Furber, E. M., Salesman, 201 Market st C
Furbush, M. A., Machinist, 212 Market st C
Furman, S. T., Carpenter, 1713 Girard av C
Furness, Howard H. L

Gale, Geo. F., Merchant, 4 Chestnut st C
Galloway, Wm., Pottery, 1725 Market st C
Gardiner, Jr., John, Brewer, 10th and Filbert sts C
Gardiner, Rich'd, M. D., N. E. 17th and Arch st L
Gardiner, Wm. D., Carriage Builder, 214 S. 5th st 2d
Gardom, George, Druggist, 19 S. 7th st C
Garrett, C. A., Photographer, 828 Arch st C
Garrett, S., Paper, 12 and 14 Decatur st C
Garrett, T., P., Photographer, 828 Arch st C
Garrett, W. E. Jr., Merchant, 224 S. Front st C
Garrett, William C., 224 S. Front st C
Garrigues, S. S., Chemist, E. Saginaw, Mich L
Garrison, John, Builder, 662 N. 10th st C
Gartley, Jos. C. L
Gaskill, Jos. W., Lumber, Green st. Wharf C
Gawthrop, Henry, Coal, 311 Walnut st C
Gay, Ware C., Secretary C
Geddes, Wm. F., Printer, 2001 Wallace st L
Geddes, W. F. Jr., Printer, 724 Chestnut st C
Geissenhainer, A. T., Clergyman, 1838 Mt. Vernon st C
Genth, F. A., Chemist, 1212 Fairmount av C
Genth, F. A. Jr., Chemist, 1212 Fairmount av 2d
Gemrig, J. H., Surgical Inst., 109 S. 8th st C
Gerker, Henry, Manufacturer L
Geyelin, Emile, Engineer, 400 Chestnut st C
Ghriskey, Chas. M., 508 Commerce st L
Gibbons, Chas., Lawyer, 242 S. 3d st L
Gifford, Elton B., Merchant, 719 Market st C
Giles, Joel, Counsellor at Law, Boston, Mass L
Gill, John A., Pattern Maker, 412 Green st C
Gillingham, Chas. M'f'r, 233 N. 20th C
Gilpin, Chas., Lawyer, 336 S. 13th st L
Gilpin, George, Broker, 1825 Delancey place L
Glass, James, Elec. Med. Apparatus, 1413 Chestnut st 2d
Gleason Wm., Millwright, 1125 Leon st C
Glenn, Geo. D., Druggist, 1326 N. 15th st C
Glessner, Oliver P., Printer, 240 Federal st L
Gloninger, Ellwood S., Student of Medicine, 239 N. 6th st C
Glocker, G., Machinist, 1019 Columbia av 2d
Gobrecht, Wm. H., M. D. L
Godey, L. A., Publisher, 6th and Chestnut sts L
Godfrey, Thos. F., Student, 1526 Palmer st C
Goehring, J. M., Mach'ist, 2144 Columbia av 2d
Goforth, Saml. M., Carver, 822 Arch st C
Goodman, George, Printer, 1 Sergeant st L
Goodwin, W. W., Meter Mfr., 1016 Filbert st C
Gordon, Isaac N., Machinist, 3820 Locust st C
Gorgas, John, Miller, Roxborough, Pa L
Goth, Anthony, Painter, Bethlehem, Pa C
Govan, J. J., Machinist, 536 E. Cumberland st C
Gowen, Franklin B., President Pottsville and Reading R. R., 204 S. 4th st C
Graeff, G. W. Jr., Editor, Germantown, Pa 2d
Graf, Chas. L., Litho. Eng., N. E. 8th and Sansom sts C
Graff, Frederick, Civil Eng., 1337 Arch st L
Grahame, I. J., Pharmacist, 29 N. 12th st C
Grant, Chas. B., Merchant, 1934 Arch st C
Gramlich, G. A., Stone Mason, Hutchinson st. and Girard av 2d
Gravenstine, G. T., Confectioner, Ridge av. ab. 12th st C
Gravenstine, J., Refrigerators, Ridge av. ab. 12th st C
Gray, Henry W., Piano Mfr., 1103 Chestnut st C
Greble, Edwin, Marble Yard, 1708 Chestnut st L
Greble, Edwin Jr., 1708 Chestnut st 1st
Greene, Wm. H., Chemist, 607 N. 18th st C
Green, Wm. R., Builder, 1520 S. 5th st C
Greer, Thomas, Machinist L
Grier, C. T., Non-conductor Covering, 218½ Walnut st C

Grier, M. J., Physician, 312 S. 15th st C
Griffith, E. E., 2327 Ridge av 2d
Griffith, Lewis, Salesman, 240 S. 2d st C
Griffith, R. E., Attorney, 1808 Locust st C
Grimshaw, R., Fire Supplies, 119 S. 4th st C
Griswold, J. W., Manufacturer, 1500 Spruce st C
Gropengiesser, J. L., Watchmaker, 814 Walnut st C
Gropengiesser, L. C., Watchmaker, 814 Walnut st C
Groesbeck, J., Accountant, 1131 Chestnut st C
Gross, O. B., Student, 407 Arch st., Camden, N. J.
Grote, G. A., Machinist, 1909 Hamilton st C
Grubb, F., Grocer, N. W. 11th & Fairmount av C
Guiteras, Calixto, Student, 113 S. 34th st C
Gumbes, Samuel W., 12th ab. Arch st L
Gumpert, B. B., M. D., 810 Franklin st L
Gutekunst, F., Photographer, 712 Arch st L

Habighurst, C. J., Engr, Navy Yard, Phila C
Hackenburg, W. B., Silk Mfr. 20 N. 3d st C
Hacker, Wm., Agricultural impl., 214 Walnut st L
Haddock, D. Jr., 426 Walnut st 1st
Haffelfinger, C. C., Publisher, 624 Market st 1st
Hagerman, J. J., Milwaukee, Wis. L
Hagert, H. S., Attorney, 2125 Sp. Garden st L
Hahn, Ignaz, Engineer, Pittsburg, Pa C
Haigh, John, Coach Painter, 1434 Girard av C
Haines, A. W., Carpenter, 1513 Marshall st L
Haines, Henry, Surveyor, 512 Walnut st C
Haines, Henry C., Germantown, Pa 1st
Haines, J. G., Treasurer, 1338 Chestnut st C
Haines, J. S., Farmer, Germantown, Pa L
Haines, Miss Jane R., Germantown, Pa L
Haines, Reuben, Germantown, Pa 1st
Haines, Robt. B., Germantown, Pa L
Hale, H. S., Manufacturer, 48 N. 6th st C
Hall, Augustus R., 709 Market st C
Hall, E. P., Secretary, 2108 Brandywine st C
Hall, Edward S., 427 Chestnut st 2d
Hall, Geo. W., 1131 Arch st L
Hall, John, Engineer, 1203 S. 13th st C
Hall, John, Machinist, 2415 Jefferson st C
Hall, Jas. S., Machinist, 1037 Almond st 2d
Hall, Mary R., Cashier, P. O. 2820 C
Hall, Oliver, 1121 Girard st C
Hall, Randolph, Machinist, 2024 Brandywine st C
Hallowell, C. F., Grocer, 923 Green st L
Hambilton, Job, Perfumer, 221 Spruce st C
Hamilton, James, Artist, 910 Chestnut st L
Hamlin, G. H., Carpenter, 1122 Green st C
Hammelt, S. M., Coppersmith, 322 Vine st C
Hance, E. H., Chemist, Germantown, Pa 2d
Hand, Alfred, Clerk, S. E. 3d and Walnut sts C
Hand, Jas. C., Merchant, 614 Market st L
Hand, S. Ashton, Machinist, 413 Cherry st C
Hand, T. C. Jr., 1506 Arch st C
Handy, E. Smith, Merchant L
Hannold, Geo., Machinist, 1221 N. 17th st C
Hanold, John, Bookkeeper, 303 New st C
Hanson, H. Cooper, 3 Logan square L
Hanson, W. R., Merchant, 1812 S. Rittenhouse square L
Harbstr, M., Hardware, Reading, Pa. 2d
Hardie, J. G., Hardware, 633 Market st C
Harding, Geo., Attorney, 900 Chestnut st L

Hare, H. B., Physician, 120 S. 22d st C
Harned, Frank P., Clerk, 140 S. Delaware av C
Harper, J. M., Plumbers' Materials, 2035 Wallace st C
Harper, T. B., Metal Bins, 2035 Wallace st C
Harper, W., Lumber Dealer, 2035 Wallace st C
Harper, Jr., Bricklayer, 623 Federal st L
Harrington, Edwin, Machinist, 504 N. 18th st C
Harris, A. N., Clerk, 1031 Marlborough st C
Harris, T. A., Dyer, 1303 Hancock st C
Harris, Geo. S., Printer, 4th and Vine sts L
Harris, Wm., Druggist, 1 Arch st L
Harrison, A. C., Sugar Refiner, 101 S. Front 1st
Harrison, G. L., Jr., M'f'r, 1704 Locust st 2d
Harrison, J., Founder C
Harrison, W. H., Machinist, 1708 Barker st C
Harrison, W. W., Sugar Refiner, Almond above Delaware av C
Hart, Abram, 1411 Arch st L
Hart, H. C., Physician, 1501 Spruce st C
Hart, S., Bricklayer, 1104 Wallace st 2d
Hart, S., Card Manufactory, 1813 Chestnut st
Hartman, J. M., Machinist, 1237 N. Front st 2d
Hartshorne, Chas., Vice-Pres't, 238 S. 3d st L
Hartshorne, H., M.D., Haverford College, Del. co., Pa. L
Hartwell, H. J., M.D., 26th ab Fairmount av C
Harvey, Alexander E. L
Hassard, Thos., C.E., 2041 N. 12th st C
Haug, J., Draughtsman, 1434 Park ave C
Haupt, H., Jr., Chemist, 2029 Green st 2d
Haupt, L. M., C.E., 110 Friedlander st C
Haworth, James, 924 Morgan st C
Hays, I. C., M.D., 1504 Poplar st L
Heath, J. A., Ornamental Plasterer, 42 N. 11th st C
Hefti, Matthias, Designer, 305 New st C
Hegenbothom, Jos., Machinist, 424 E. Cumberland st C
Heller, C. F., 853 N. 20th st 2d
Heller, C. S., Inst. Maker, 33 N. 7th st C
Hellowell, J., Machinist, 1600 Hamilton st C
Helme, Wm., Gas Meters, 1117 Cherry st 1st
Henderson, Edward, Hatter, 19 N. 3d st L
Henderson, Wm., M. Engineer, 3843 Spring Garden st C
Hendry, J. A., Leather Merchant, 67 Chestnut L
Henry, Frank, Dealer, 103 N. 10th st C
Henry, Geo. H., Salesman, 113 Arch st C
Henry, G. W., Jr., Clerk, 139 S 4th st C
Henszey, S. A., R. R., Front and Willow sts C
Henszey, S. C., Salesman, 954 N. 6th st L
Henszey, W. H., Draughtsman, 1312 Filbert st C
Henzey, Jos. G., Mining, 110 S. 4th st C
Herkendon, H. C., Machinist C
Hering, Rudolph, C.E., 2226 Brandywine st C
Herst, P., Hatter, 218 Arch st C
Herwig, Emilianus, Apothecary, 3d & Brown C
Herzberg, I., Watchmaker, 135 N. 6th st C
Hess, Eli, 1434 Fairmount av L
Hess, J. M., Machinist, 1315 Buttonwood st C
Hessen, J., Machinist, 1600 Hamilton st 2d
Hewitt, G. W., Architect, 310 Chestnut st C
Hewett, J., Merchant, 409 Market st L
Hewston, G., Physician, 766 Vine st L
Heyl, H. R., Manufacturer, 4050 Aspen st C
Heysinger, I. W., Physician, 1133 Girard av C
Hibbs, J. M., M'f'r, 1330 Buttonwood st C

Hickson, C. O., Machinist C
Hiester, A. S., Dealer, 839 N. 5th st C
Hillebrand, L., M'f'r of Locks, 110 S. 8th st C
Hiltebrand, E., Librarian, 15 S. 7th st C
Hinchman, J. H., Clerk, 606 Sansom st C
Hipple, W. Hall, 940 Race st L
Hirst, Jos., M'f'r, Roxborough C
Hitchcock, H. S., Teacher, Broad & Pine sts C
Hobbs, C. M., Signal Officer, Pike's Peak, Col. C
Hoehle, C., Draughtsman, 1365 Beach st C
Hoffman, Geo. E., Engineer, 259 S. 17th st C
Hoffman, H. J., Manufacturer C
Hoffman, J. W., C. and M. E., 259 S. 17th st C
Hofstetter, Aug., Binder, 19 N. 10th st C
Hofstetter, Geo., M'f'r, 111 S. 8th st C
Hohenadel, John, Jr., 29th and Penna. av 2d
Holcroft, R., Engineer, 325 Albert st C
Holman, D. S., Actuary, 15 S. 7th st 1st
Holman, Lydia, 431 Arch st C
Holmes, Seth C. L
Hollis, P. C., Accountant, 407 Library st C
Hollinshead, B. M., 537 N. 7th st L
Hollowell, D. S., Bookkeeper, Frankford C
Holzer, E. R., Painter, 1507 Stiles st C
Hook, H. W., Metal Dealer, Broad & Hamilton sts C
Hoopes, D. J., Jeweler C
Hoover, H., N. Constructor, 323 Wharton st L
Hoover, J. Eves, Jr., Ink M'f'r, 416 Race st C
Hoover, Jos. E., Ink M'f'r, 416 Race st C
Hope, Thos., Machinist, 2011 Cedar st C
Hopper, Thos. C., Gas Maker, N. W. 22d and Arch sts C
Horne, C. H., Merchant L
Horne, C., Undertaker, 23 N. 11th st C
Horstmann, F. O., M'f'r, 5th & Cherry sts L
Hoskins, John, 720 Wood st 2d
Hoskins, Raper, Fancy Store, 913 Arch st C
Houghton, H., Agent C
Houston, Prof. Edwin J., Cent. High Sch'l 1st
Houston, J. F., Civil Engineer, Columbia, Pa. L
Howard, C. W., Inventor, 1505 Ridge av C
Howard, G. C., Machinist, 13 S. 18th st L
Howard, W. H., Media, Del. co., Pa. L
Howe, H. M., Physician, 1606 Locust st 1st
Howell, G., Paper Hangings, 900 Chestnut st C
Howell, W., Paper M'f'r, 12 S. 6th st L
Howell, Z. C., Paper Hangings, 12 S. 6th st C
Howson, H., Patent Attorney, 119 S. 4th st 1st
Hudson, Thomas, 1022 Wallace st C
Huff, J. W., Printer, 705 Jayne st C
Hughes, Henry, Merchant, 1020 Green st C
Hughes, W. W., Iron Works, 139 N. Front st C
Hulinger, J. W., Teacher, Beverly, N. J. C
Humphrey, H. C., Chemist, 113 Walnut st C
Hunt, J. G., Physician, 123 N. 10th st C
Hunt, Jos., Mining Eng., Catasauqua, Pa. C
Hunter, J., Calico Printer, 55th & Paschall L
Hunter, J. C., Plumber, 1150 S. Broad st L
Hunter, Jos. L., Engineer, 126 Walnut st C
Hunter, H., Gas Fitter, 55th & Paschall st L
Hutchins, M. F., Furniture, 837 Market st C
Hutchinson, J., California L
Hutchinson, Israel P. 1st
Hutchinson, Robt., Notary, 1416 Fairmount av L
Hutton, Addison, Architect, 215 S. 5th st C
Hutton, Finley, Builder, 120 N. 13th st C
Hyer, Grainger, Physician, 207 S. 13th st C

Iddings, Frank H., Clerk, 421 N. 7th st C
Ingersoll, Harry, U. S. Navy L
Ingham, W. A., President, 320 Walnut st C
Irwin, J. H., Morton, Del. co., Pa. C
Ivens, A. B., Teacher, Friends' Central Sch'l L

Jacoby, G. W., Marble Dealer, 2025 Market st C
Jacoby, Otto, Brewer, 913 & 915 N. 4th st C
Jack, Louis, Dentist, 1533 Locust st C
Jackson, B. F., Printer, 404 Library st C
Jackson, G. W., Printer, 404 Library st C
Jackson, S., Pyrotechnist, 1414 Ellsworth st C
James, Bushrod, W., Physician, 18th and Green sts C
James, Samuel, Machinist, 519 N. 43d st C
Janney, B. S., Jr., Grocer, 123 Market st C
Jarrett, Wm., Clergyman, 523 Chatham st C
Jayne, E. C., Druggist, 42 Chestnut st L
Jeanes, J. T., Merchant, 1023 Arch st L
Jeffreys, Wm., Blacksmith L
Jenks, B. H., Machine Maker, 402 Locust st L
Jessup, Alfred D., 1426 Walnut st 1st & L
Jewell, Leonard, Merchant, 1425 Chestnut st L
Johnson, Chas. Enen, Ink M'f'r, 500 S. 10th st L
Johnson, E. H., Mach'st, 23d & Wash'ton av C
Johnson, Geo. L., 5th and Library sts L
Johnson, Geo. R., Tinsmith, 7th and Sansom sts L
Johnson, Orlando, Machinist, 1345 Buttonwood st C
Johnson, Robt. P., Carpenter, 509 Locust st C
Jones, Alfred, Ross st, Germantown L
Jones, Alfred, Physician, 200 S. 12th st C
Jones, Alonzo L., Steam-fitter, 51 S. 4th st C
Jones, George, Teacher, 186 N. Front st L
Jones, Geo. W., Clerk, 1328 Spruce st L
Jones, J. P., Merchant, 1608 Market st 1st & L
Jones, J. Howell, 1834 Filbert st 2d
Jones, Nathan F., C. E., Norristown, Pa. L
Jones, Owen, Iron Founder, 16th and Market sts L
Jones, Owen, Merchant, 200 Market st L
Jones, Warner C., Hardware, 2809 Girard av L
Jones, Washington, Steam Engineer, Richmond and Ball sts L
Jordan, John, Jr., Merchant, Historical Society, Spruce above 8th st L
Justi, Henry D., Dentist, 516 Arch st C
Justice, Alfred B., Hardware, 14 N. 5th st 2d
Justice, Howard R., Salesman, 14 N. 5th st C
Justice, Lemuel B., Machinist, 619 N. 7th C

Kaighn, Mary M., Teacher, 1419 Walnut st C
Kain, Henry C., Teacher, 524 Cooper st, Camden, N. J. C
Keefer, Wm. W., 1416 Chestnut st. In trust for Wm. B. Keefer 1st
Keeley, Jerome, Tin Plate, 432 Market st 2d
Kelly, John F., Gentleman, 524 Walnut st C
Kelley, Henry H., Druggist, 1706 Green st L
Kelly, Wm. D., Attorney-at-law, Myrtle and N. 41st sts L
Kelly, Wm. S., Wood Machine Manf., 2019 Vine st C
Kendall, E. O., Teacher, Univ. Penna. C
Kennedy, Elias D., Broker, 308 Walnut st 2d
Kennedy, John M., 1423 Arch st 1st

Kern, John, Draughtsman, 1015 Race st L
Kern, Wm. E., Drawing Teacher, 1015 Race st C
Kerr, David B., Supt., 3528 Fairview st C
Kerr, James K., Machinist, 1218 Chestnut st C
Kerr, Wm., Engineer, 1208 S. 15th st C
Kershaw, John G., Lawyer, 451 N. 6th st 2d
Ketcham, Hulings, C., Carpenter, 811 Fairmount av C
Ketterlinus, E., Printer, N. W. 4th and Arch sts L
Kiehner, J. T., Merchant, 812 E. York st C
Kile, John, Pattern Maker, 808 N. 17th st L
Kildare, Wm. P., Printer, 736 Sansom st C
Kilgore, John, House Carpenter, Wood and Juliana sts L
Killie, John T., 1822 Green st 1st
King, Thomas, Carpenter st L
King, Wm. F., Draughtsman C
King, Wm T., Clerk, Camden, N. J. L
Kinsey, John L., Clerk, 3d and Vine sts C
Kinsey, Wm., Jr., Morocco Manf., 3d & Vine sts C
Kirk, J. J., Clerk, 303 Walnut st 1st
Kirk, Geo. H., 1528 Brown st 1st
Kirkbride, Thos. S., Physician, 44th and Haverford st C
Kirkhuff, J. D., Teacher, Broad and Pine sts C
Kirkpatrick, Alex. E., Hide Dealer, 3d and Vine sts C
Kirkpatrick, Edwin, Merchant, 3d and Vine sts C
Kirkpatrick, Frank L., Watchmaker, 1416 Chestnut st C
Kirkpatrick, Jas. A., Asst. Supt. Girard Estate, 2014 Vine st L
Klapp, Jos., Physician, 622 Spruce st L
Klemm, Fredk, M'f'r, 132 N. 5th st C
Knapp, G. S., Inventor, 269 Girard av C
Kneass, Napoleon B., Saddle Manf., 2121 Columbia av L
Kneass, Strickland, Civil Eng., 233 S. 4th st C
Knight, Daniel R. L
Knight, E. C., Merchant, 1605 Chestnut st L
Knight, Hartley, Merchant, 1222 Chestnut st 2d
Knight, Jacob B., Eng., 15 S. 7th st 1st
Knight, W. A., Hardware, 514 Commerce st C
Knorr, J. Francis L
Koenig, Geo. A., Prof. Chemistry, 3603 Atlanta st C
Koons, Chas. B., Heaters, 1128 Market st C
Kramer, Henry, 1315 Palmer st 2d
Krider, Peter L., Silversmith, 618 Chestnut st C
Krumbhaar, Alex., File Manufactory, 1601 Spring Garden st C
Krumbhaar, Wm. T., Iron Founder, 115 S. 21st st C
Kuhn, Chas., Broker, 1712 Spruce st L
Kuhn, C. Hartman, Broker, 1712 Spruce st L
Kuhn, Hartman, Jr., 210 Walnut st L
Kutz, Geo. F., M. Engineer, Mares' Island, San Francisco, Cal. C

Lagomarsino, A., M'f'r, 8th and Christian st C
Laing, Henry M., Shoe Findings, 335 N. 11th st L
Lamasure, Edwin, Accountant, 134 S. 2d st C
Lambdin, Jas. R., Artist, 1224 Chestnut st L
Lambert, John, Attorney, 420 Walnut st L
Lamborne, Robt., President, S. E. cor. 5th and Library st 2d
Lancaster, Wm. H., Carpets, 756 S. 2d st C
Lance, F., Dyer, 1406 Germantown av C
Lang, Geo. S., Engraver, Media, Del. Co., Pa. C
Langford, John, Physician, 5th and Christian sts C
Large, Daniel, Engineer, Poplar ab 2d L
Larkins, Frank J., Rigger, 238 S. 11th st C
Laroche, R., Physician, 242 Walnut st L
Latham, Richard, Engineer, 1708 Chestnut st C
Latimer, Thos., 432 Library st C
Lawrie, C. W., Machinist, S. E. cor 10th and Locust sts C
Lea, Henry C., Pub., 706 Sansom st L
Lea, Isaac, Bookseller, 1622 Locust st L
Lea, M. Carey, Attorney, 426 Walnut st L
Leavitt, E. D., M. E. 2d
Le Boutillier, Roberts, Germantown L
Le Conte, John, Physician, 321 Locust st L
Lee, Geo. Burtis, 533 N. 6th st C
Lee, Geo. F., Builder, 533 N. 6th st L
Lee, Thos., Draughtsman, 233 S. 4th st C
Lee, Thos. D., Grate Maker, 329 S. Broad st L
Leeds, Albert R., Teacher, Hoboken, N. J. 2d
Leeds, B. Franklin, 1520 Market st 2d
Leeds, Josiah W., Real Estate, 528 Walnut st 2d
Leffman, Henry, M.D., 517 Wood st C
Lejee, Wm. R., Broker, 1801 Walnut st L
Lennig, Chas., Wools, 112 S. Front st L
Lenthall, John, C. E., Washington, D. C. L
Leguin, G. E., Merchant, 208 West st, N. Y. C
Leroy, A. C., Draughtsman, 1600 Hamilton st C
Lesley, Jos., Secretary, 233 S. 4th st C
Le Van, W. B., Engineer, 3607 Baring st L
Lever, Jas. S., Bookbinder, 46 N. 7th st C
Levering, W. M., Draughtsman, 410 Walnut st 2d
Levick, R. H., Merchant, 724 Chestnut st C
Lewis, Enoch, Purchasing Agt., 233 S. 4th st C
Lewis, E. J., Physician, 126 Chestnut st C
Lewis, Ed. M., President, 427 Chestnut st C
Lewis, Geo. F., Plate Printer, 33 S. 3d st L
Lewis, Henry Carvill, East Washington Lane, Germantown L
Lewis, Milfred, Mechanic, 33d & Powel'n av 2d
Lewis, S. T., Machinist, 304 N. 21st st C
Lewis, W. J., C. E., San Francisco, Cal. L
Lewis, Wilfred, Mechanic, 33d & Powelton 2d
Lex, J. H., Secretary, 34 N. 5th st L
Lightfoot, Jesse, Lawyer, 61 Harvey st, Germantown C
Lilly, W., Coal and Iron, 303 Walnut st C
Lindenthal, G., C. E. C
Lindsay, R., Publisher, 528 Franklin st L
Linville, J. Hays, Engineer and Architect, 218 South Fourth st C
Lipman, H. L., Stationer, 411 Walnut st C
Lippincott, C., Manufacturer, 916 Filbert st C
Lippincott, Hilles, Bookkeeper, 920 Franklin st C
Lippincott, J. B., Publisher, 717 Market st 1st and L
Lippincott, Josh., Jr., Clothier, 538 N. 6th st C
Little, Thomas, Builder, 313 S. 12th st C
Littleton, Wm. E., 514 Walnut st 1st
Livesey, John, 1123 Arch st 1st & L
Lloyd, Mrs. F., Teacher, 1615 Chestnut st C

Lloyd, Malcolm, Petroleum, 307 Walnut st C
Loftis, P. S., Jeweler, 61 N. 8th st C
Loiseau, E. F., M'f'r, Port Richmond C
London, W. E., Machinist, 22d ab Arch st C
Longacre, Matthias R., Engraver and Lithographer, 7th and Market sts C
Longstreth, Ed., Machinist, 500 N. Broad st C
Longstreth, J. Cooke, Lawyer, 125 S. 7th st C
Loper, Capt. R. F. L
Loughlin, W., Jr., Lawyer, 632 Christian st 2d
Lovegrove, T. J., Boiler Insp., 125 N. 4th st C
Lovering, Jos. S. L
Lowrys, Elizabeth C., 1114 Pine st C
Luder, Thomas L. L
Lukens, Amos, Blacksmith, Plymouth Meeting P. O., Montgomery co., Pa. L
Lukens, David L., Clerk, 1600 Hamilton st 2d
Lukens, Jas. T., Dry Goods, 531 Marshall st L
Lukens, Michael, Bookkeeper C
Lush, John F., Carpenter, 518 Federal st C
Luthy, Otto, Chemist, 451 N. 4th st C
Lyman, Benjamin S., Mining Engineer, Northampton, Mass. C
Lynn, John W., 426 S. Delaware av 1st
Lyon, C. Wesley, Chemist, 215 S. Front st C

Maas, Chas. E., Engraver, 1619 Norris st L
Maas, Wm. A., Printer, 1337 Mt. Vernon st L
MacCallum, Hugh, Machinist, Germantown C
MacDonald, Charles, C.E., 80 Broadway, N.Y. C
MacDowell, William H., Engraver, 1028 Chestnut st C
MacHarg, E., Teacher, S. W. 16th & Spruce C
MacPherson, Angus N., Bordentown, N. J. C
Madeira, J. F., M'f'r, 1615 N. 9th st C
Magargee, Charles, Paper Dealer, 6th & Jayne sts L
Magee, Frank H., 1219 Arch st 1st
Magee, James, Saddler L
Magee, James R., 1219 Arch st 1st
Magee, Michael, Saddler L
Maloy, Chas. W., 1515 S. 5th st 2d
Marcy, L. J., Optician, 1340 Chestnut st C
Marembeck, G. W., Heaters and Rangers, 2145 N. 7th st C
Maris, John M., Chemist, 711 Market st C
Marriner, S. R., Carpenter and Builder, 1318 N. 19th st C
Marsh, Benj. V., Merchant, 309 Market st C
Marshall, Samuel R., Machinist, 923 N. Broad st C
Marshall, W. M., M'f'r, 1529 Green st C
Marter, J. B., Sewing Machine C
Martin, Jas., Jr., Machinist, 1 Coombs Alley L
Martin, Wm. N. C
Martin, W. A. K., Scholar, 856 N. Broad st C
Martindale, J. C., Cashier, 322 Penn st, Camden, N. J. C
Martindell, G. L., Milliner, 10 N. 8th st 2d
Marx, Geo. W., Dyer, 840 N. 3d st C
Mason, Jas. S., M'f'r, 140 N. Front st 1st
Mason, Samuel, 220 S. 4th st L
Massey, A. P., M'f'r, Cleveland, Ohio C
Massey, W., Brewer, 10th and Filbert sts 1st
Matlack, J. R., Physician, Race & Chester sts L
Matlack, J. David 2d
Mattis, H. J. M., Merchant, 1706 Girard av C
Matthews, W. G., 2022 Mt. Vernon st 1st
Matthews, Wm., 2022 Mt. Vernon st 1st
Maule, E., Lumber Dealer, 2500 South st C
Mecke, Fred. T., M'f'r, 124 Church st C
Megargee, S. J., Merchant, 20 S. 6th st C
Megargee, Theo., Paper M'f'r, 20 S. 6th st C
Meigs, H. V., Machinist C
Meigs, J. A., Physician, Broad and Lombard sts L
Melchor, Martin V. B. 1st
Mellor, Alfred, Chemist, 218 N. 22d st C
Mellor, Thos., Merchant, Chelton Hills, Pa. L
Menamin, R. S., Publisher, 515 Minor st C
Merklee, Chas. K., M'f'r, 1320 Wallace st C
Merrick, J. Vaughan, Roxborough, Phila., 1st and L
Merrick, Samuel G., 3926 Walnut st 2d
Merrick, Wm. H., Machinist, 230 S. 3d 1st & L
Messchert, M. H., Lawyer, 1528 Arch st L
Meyer, Conrad, Pianos, 722 Arch st L
Meyer, C. Eugene, Pianos, 722 Arch st C
Michener, E. P., Civil Engineer, 1917 N. 12th st C
Mickley, Jos. J., Piano M'f'r, 626 Wood st C
Mickley, Jos. P., U. S. N., Irving House C
Middleton, C., Iron, 2d and Willow sts L
Middleton, C. W., Iron, 945 Ridge av 2d
Middleton, H. W., Iron, 945 Ridge av 2d
Middleton, John W., Iron, 616 N. 5th st C
Middleton, Nathan L
Miles, Fred. B., Engineer, 24th and Wood sts C
Miller, Adolph W., Physician, 860 N. 5th st C
Miller, D. K., Lock M'f'r, 712 Cherry st C
Miller, Edward, C. E., 246 Spruce st L
Miller, E. W., Bookbinder, 1702 Vine st L
Miller, Geo. S., Bookkeeper, 505 Market st C
Miller, Jas. H., Brass Founder, 1028 Spring Garden st C
Miller, W. H., Draughtsman, 1817 Jefferson st C
Miller, Jos. S., M'f'r, 1210 Ridge av C
Mills, Chas. K., Physician, 1502 Columbia av C
Mills, Jos. H., Silver Plater, 508 Poplar st C
Milne, Caleb J., M'f'r, 2030 Walnut st L
Milne, F. F., 1520 Arch st C
Mingus, P. P., Blacksmith, Cherry and Juniper sts L
Minich, A. R., Physician, 2228 N. Front st C
Minister, Jos. B., Color Mixing, 18th and Washington av C
Mintzer, Geo. E., 752 N. 20th st C
Missemer, J. H., Salesman, 302 Market st C
Mitchell, J. B., 715 Market st 1st
Mitchell, Jos. E., Merchant, 310 York av C
Mitchell, J. Henry, Machinist, 604 Beach st C
Mitchell, J. Howard, Merchant, 14 N. 5th st C
Mitchell, Wm. A., Merchant, 224 Federal st, Camden, N. J. L
Moody, Edward F., Camden, N. J. L
Moore, B. H., Paper M'f'r, 27 N. 6th st 1st & L
Moore, Geo. R., Rev., 1820 Cayuga st C
Moore, Jas. C., Oil M'f'r, 218 N. 2d st C
Moore, Henry D. 1st & L
Moore, Jas., Machinist, 16th and Buttonwood sts 1st
Moore, Wm. H., Undertaker, 1610 Arch st L
Moore, Wm. J., Carpenter, 1719 S. Rittenhouse st L
Moorehouse, R. O., Machinist, 13th and Buttonwood sts 2d

Morgan, Alex. H., Engineer, 1531 Wallace st C
Morgan, Chas. W., Engineer, Frankford C
Morgan, Thos. A. L
Morrell, D. J., 218 S. 4th st 1st
Morrison, Benj., Patent Solicitor, 228½ Walnut st C
Morris, Daniel J. 1st and L
Morris, Chas. M., Merchant, 29 Strawberry st C
Morris, Henry. 207 Spruce st L
Morris, Henry G., Iron M'f'r, 5th and Washington av L
Morris, Israel, 1608 Market st 1st
Morris, Israel W., 238 S. 3d st C
Morris, Wistar, 3d and Walnut sts L
Morris, J. Cheston, Physician, 1514 Spruce st C
Morrison, Alex., M'f'r, 3739 Spruce st C
Mortimer, Chas., Copper Plate Printer, 297 Vine st L
Morton, Prof. Henry, President, Hoboken, N.J. L
Morton, Rev. Henry J., 909 Clinton st 1st
Moss, Theodore F., Mining Engineer L
Mott, G. S., Telegrapher C
Muckle, Alex., Chemist, 1321 N. 19th st C
Mucklé, M. R., General Manager, 600 Chestnut st C
Munns, Cuthbert L., Jr., Watchmaker, 731 Spruce st C
Muringer, Julius, Chemist, 11th & Bainbridge st C
Murphy, Howard, C. E., 224 S. 5th st C
Murphy, Wm. C., Painter, 181 S. 2d st L
Murray, Chas. W., Stereotyper L
Murray, Matthew, Machinist L
Murray, Peter, Founder, 2214 Brandywine st C
Murray, Samuel A., Jr., 1711 Fairmount av C
Murta, John P., Accountant, 249 S. 8th st L
Myers, Geo. M., Painter, 232 Christian st C
Myer, Isaac, Attorney, 152 S. 4th st C
McAllister, John L
McAllister, W. Mitchell, Optician, 728 Chestnut st L
McAlpine, Daniel, Machinist, 1422 N. 18th st C
McArthur, John, 408 S. Broad st L
McArthur, John, Jr., Architect, 1331 Chestnut st C
McBride, Thomas, Hydraulic Engineer, 243 S. 6th st C
McCall, Peter, Attorney-at-law, 224 S. 4th st C
McCambridge, Richard, Brass Founder, 527 Cherry st C
McCambridge, S., Saddler, 523 Cherry st C
McCaffrey, Hugh, File M'f'r, 1736 N. 4th st C
McCaffrey, John, File M'f'r, 1615 N. 4th st C
McCahan, Jas. M. M. G. B., 1813 S. 2d st C
McCallion, R. W., Blacksmith, 810 S. 11th st C
McCarter, Wm., Painter, 1515 S. 6th st C
McCausland, Wm. J., M'f'r, 132 Market st C
McClure, John, Builder, 21 S. 16th st L
McCollin, James G., 1600 Hamilton st 2d
McCollom, T. C., C. E., 1811 Lee st C
McConn, John, Inventor, 920 Walnut st C
McConn, Wm. S., Steam Heaters, 920 Walnut st C
McConnell, Alex., Tar and Pitch, 2929 Gray's Ferry rd C
McCorkle, D. C. W., Bookkeeper, 1117 Girard av C
McCormick, A. A., Engraver, 1006 Chestnut st C
McCowan, John L
McCowen, Wm. A., Machinist, 1936 Christian st C
McCully, H. G., Clerk, 5th and Chestnut st C
McCurdy, John R., Manufacturer, 116 Arch st L
McElroy, Jos. B., M'f'r, 2426 Lombard st C
McFadden, Wm. H., C. E., 13th and Spring Garden sts 2d
McGinn, John J., Engineer, 2255 Palethorp st C
McIlvaine, A. Robinson, Drug and Spice Mill, 15th and Hamilton sts L
McInnes, J. T., Lime Merchant, 9th below Master st C
McIlvaine, Wm. L
McIntyre, C., House Carpenter L
McKean, W. V., Manager *Public Ledger*, 6th and Chestnut sts C
McKennan, Jas. W., M'f'r, 738 S. 19th st C
McKinley, Benj. B., Teacher, 425 S. 16th st L
McKnight, Wm., Shoe M'f'r, 32 S. 4th st C
McMinn, H. S., C. E., Pennington, N. J. 2d
McMurray, Andrew S., Physician, 325 Pine st L
Nauman, Wm. H., Engineer, 1528 N. 19th st C
Naylor, Jacob, Iron Founder, Front and Girard av L
Neal, Wm., 536 N. 7th st L
Negus, J. Engle, Merchant L
Nelms, Henry, Gold Beater, 46 N. 7th st L
Nevil, Wm. H., Morocco Manf., 144 Margaretta st C
Newmann, Joseph, Manufacturer, 919 Race st 2d
Newman, John S., Jeweler, 433 Green st C
Newman, R. M., Com. Merchant, 8 S. Front C
Newbold, J. S., Merchant, 719 Pine st L
Newbold, T. M., Druggist, 105 S. 41st st 2d
Newcomer, U. S., Bingham House C
Newell, H., Chief Eng., Navy Yard C
Newell, W. H., Machinist, 816 Spr. Garden st C
Newhall, George, 528 Spruce st C
Newhall, G. M., Sugar Refiner, 225 Church st C
Newlin, John S L
Nichol, J. H., Leveler, 932 N. 2d st C
Nicholls, E., Com. Traveler, 1937 Camac st C
Nicholson, C. L., Lumber, N. W. 7th and Carpenter sts L
Nicholson, Jos., 808 N. 16th st C
Nicholson, Richard L L
Nieland, J., Machinist, 410 N. 10th st C
Norris, I., Jr. Physician, 1424 Walnut st C
Norris, Richard 1st
Norris, Samuel 1st
Norris, Thad., Jr. Engineer, 221 S. 18th st C
North, G. W., 3718 Locust st C
Nourse, J. E., Prof. U. S. N., Washington, D.C.
Nugent, E., Druggist, 18 N. Front st C
Nystrom, J. W., C. E., 262, S. 10th st L

Oat, G. R., Coppersmith, 1307 Arch st C
Oat, Jos., Coppersmith, 232 Quarry st C
Odenatt, M. H., Millwright, 1527 Savery st C
O'Driscoll, C. F., Stereotype Founder L
Oesterle, P., Draughtsman, 232 Quarry st C
Ogram, Thomas, 1521 Ogden st 2d
O'Hara, J. H., Tailor, 29 N. 6th st C
Olier, T. K., Sewing Machines, 1106 Chestnut st C
Oliver, G. L., 1112 Arch st 1st
Olsen, T., M. E., 1911 N. 11th st C

O'Neil, J., M. E., P. O. Box 1455, Bridgeport, Conn C
O'Neil, G., Chemist, 1909 Ellsworth st C
Opdyke, S. B. Jr., C. E., 1112 N. 15th st C
Ord, J., Architect, 215 S. 5th st C
Orr, H., Printer, 202 Chestnut st L
Orum, M. L. Machinist, 418 N. 12th st C
Ott, G. F., Coppersmith, 213 Buttonwood st C
Oart, L., Black and White Smith, Riverton, N. J. C
Outerbridge, Alex. E. Jr., Assay Laboratory, U. S. M. C

Paddock, F. L., C. E., 1827 Haverford st C
Palmer, B. F., Surgeon Artist, 1609 Chestnut st L
Pancoast, A., Chemist, 1030 Chestnut st C
Pancoast, C. S., Attorney, 116 Walnut st C
Pardee, A., Coal, Hazelton, Pa 1st
Pardee, A. Jr., Iron, 303 Walnut st 1st
Pardee, Calvin, Coal, Hazleton, Pa 1st
Parke, J. P., Trenton, N. J. C
Parker, G., House Carpenter, Berkley, Gloucester co, N J. L
Parker, J. L
Parker, W. H., Teacher, School 8th and Fitzwater sts C
Parkinson, R. B. L
Parrish, D., Druggist, 1017 Cherry st L
Parrish, Edward, C. E., Phila
Parrish, R. A. Jr., Counsellor at Law, 229 S. 6th st C
Parry, C. T., Machinist, 500 N. Broad st L
Partrick, J., Telegrapher, 38 S. 4th st C
Paterson, W. F., Chf. Eng., Doylestown, Pa C
Patterson, A. H., Clerk, 419 N. 6th st 2d
Patton, T. R., Merchant, S. E. 13th and Locust sts 1st
Paxson, H., Secretary, Trenton, N. J. C
Peacock, H. H., Fancy Morocco Cases, 610 Chestnut st C
Peele, E., Sewing Machines, 1911 N. 12th st C
Peltz, P. G., Eng. U. S. N., Schuylkill Falls L
Pemberton, Henry, Gentleman, 1947 Locust st C
Pemberton, Harry Jr., Chemist, 1947 Locust st C
Pennell, L., Bookkeeper, 1 Walnut st 2d
Pennock, J. S., Plumber, 805 Franklin st C
Perkes, C., Brass Founder, 627 Arch st C
Perkins, A. R., Merchant, 102 S. 9th st L
Perot, T. M., Druggist, 1810 Pine st L
Perry, W. G., Bookseller, 728 Arch st L
Peters, C. J., Hat Manufacturer, S. E. 5th and Market sts C
Peterson, R. E. Jr., 131 S. 2d st 2d
Peterson, W., Chemical Works, 1 Arch st C
Petraus, V., Chemist, 231 S. Front st C
Pettit, H., C. E., 1509 Walnut st C
Pettitt, W., 2131 Mt. Vernon st L
Philips, W. J., S. W. 5th and Chestnut sts C
Phillips, Chas. C., 934 N. 5th st 1st
Phillips, Cyrus, 617 Arch st C
Phillips, G. Brinton, Chemist, 8 N. 7th st C
Phillips, H. C., Photographer, 1206 Chestnut st C
Piers, Louis J., Accountant, 1201 Green st L
Pierce, Parker D., Druggist, N. E. cor. 2d and Callowhill sts C
Pile, Wm. H., Printer, 422 Walnut st C
Pile, Wm. H., 1101 Locust st C
Pistor, Philip, Draughtsman, 2318 St. Alban's Place C
Platt, Franklin, Geologist, 615 Walnut st C
Pleasanton, Gen. A. J., 918 Spruce st 2d
Poole, Alfred D., Machinist, Wilmington, Del C
Postdamer, T B., Lithographer, 321 Chestnut st C
Potter, Thos., Oil Cloth Mfr., 418 Arch st L
Potts, Albert, Iron Merchant 238 N. Front st L
Potts, Edward, Clerk, 238 S. 3d st C
Pounds, Wm. H., Brass Worker, 15 N. 7th st C
Powell, John M., 3613 Powelton av 1st
Powell, Samuel W., Student, Easton, Pa C
Powers, Thos. H., Mfg. Chemist, 9th and Parrish sts L
Pratt, A. H., Advertising Agent, N. E. cor. 5th and Walnut st C
Pratt, N. A., M. D , 104 Chestnut st C
Pratt, Daniel R., Machinist, Worcester, Mass L
Price, Chas. H., Cashier, 306 Walnut st 2d
Price, Jacob S., Carpenter, N. W. cor. 11th and Shippen sts L
Price, Joseph L
Price, Samuel, Bricklayer, Darby, Pa L
Price, Wm. S., Attorney at Law, 633 Walnut st C
Prince, John F., Marble, 2214 Chestnut st C
Prince, Sam'l F., 2214 Chestnut st C
Prince, Sam'l F. Jr., M. E., 2214 Chestnut st C
Prindle, F. C., C. E., 10 S. Del. ave C
Pugh, Chas. E., 3003 Market st C
Pugh, J. H., Silver Plater C
Purves, A., Merchant, 17 South st L
Purves, Chas., 17 South st C
Pusey, Joshua, Mfr C

Quig, Henry, Copper Plate Printer, 3762 Frankford rd L
Quimby, Benj. F., 224 S. 5th st 2d

Ralph, Alex., Tobacconist, 115 Arch st C
Rand, B. H., M. D., 1615 Summer st L
Rand, Theo. D., Attorney, 17 S. 3d st L
Randall, J. Colvin, 114 S. 16th st 2d
Randolph, Evan, Merchant, 2002 Arch st L
Randolph, William, Clerk, Arch and 20th sts L
Rawle, Jas., Manufacturer, Bryn Mawr, Pa C
Rea, W. Howell, Carpenter, 1803 Poplar st C
Reaney, Robt. L., Machinist, Frankford L
Redfield, Jno. H., 216 W. Logan Square 1st
Redfield, Robt. S., 1600 Callowhill st 1st
Reed, Henry H., Merchant, 1425 Chestnut st L
Reeves, Ellwood L
Reeves, Sam'l J., 414 Walnut st L
Reid, A. H., Manuf., 1621 Market st C
Reigner, H. F., Machinist, 1326 Mount Vernon st C
Remsen, Geo. C., Publisher, 624 Market st 1st
Rex, Abraham, 1035 Walnut st C
Reynolds, Jesse, Heaters and Ranges, 13th and Filbert sts C
Rhoads, Joshua, Physician, Jacksonville, Ill L
Rhoads, Wm. G., Plumber, 1221 Market st C
Rice, D. E., M. D., 1522 Callowhill st C
Rice, George, 1st
Rice, Jas. D., 11 S. 7th st 2d

Rice, John, 129 S. 7th st 1st
Richards, G. W., Manufacturer, cor. Broad and Spruce sts L
Richards, John, Atlantic Works, 22d ab. Arch 1st
Richards, P., Tack Maker, Germantown C
Richards, T. W., Architect, 3332 Chestnut st C
Richards, S. R., Jr., Clerk, 1520 Race st C
Richards, Wm. J., Bookkeeper, 48 Wistar st., ab. 11th L
Richardson, David, Physician, Almshouse C
Richardson, George J., Fire Arms L
Ridgeway, Thos., 1705 Walnut st 1st
Riehlé, Henry B., Scales, 9th ab. Master st C
Rimby, A., Manufacturer, 1615 N. 9th st C
Ritchie, C. D., Conveyancer, 508 Walnut st C
Riter, John A., Builder, 610 N. 10th st L
Rittenhouse, Henry N., Mfg. Chemist, 218 N. 22d st C
Robbins, John, Steel Manufacturer, 917 Shackamaxon st L
Roberts, Alfred R., C. E., 407 Walnut st C
Roberts, Caleb C., Adams Express Co., 1118 Arch st L
Roberts, Chas., Mfr., 410 Race st C
Roberts, C. J., Dry Goods, 912 Chestnut st 2d
Roberts, Edward, N. E. 11th and Spruce sts L
Roberts, Elihu, Secretary, 307 Walnut st L
Roberts, George B., 1901 Spruce st 1st
Roberts, George Theo., 314½ Walnut st 1st
Roberts, Howard E., Machinist, 1315 Green st C
Roberts, Percival, 265 S. 4th st 1st
Roberts, Sol. W., C. E., 407 Walnut st 1st & L
Roberts, W. Milnor, C. E., Iselin, N. J. L
Robinson, C. W., Conveyancer, 812 Walnut st C
Robinson, E. W. L
Robinson, Geo. M., Eng. U. S. R. M., 144 Mifflin st C
Robinson, W. Massey, Brewer, 10th and Filbert sts C
Rogers, Fairman, 202 W. Rit'house sq. 1st & L
Rogers, Fairman, In trust for Franklin A. Dick, 1709 Locust st 1st
Rogers, Prof. Rob't E,, 1004, Walnut st L
Rogers, T. M., Draughtsman, 716 Spruce st C
Rogers, W. D., Coach Maker, 1009 Chestnut st C
Rohn, Christian, M. E., 1914 N. 11th st C
Rohrman, Jos. B , Clerk, 610 Cherry st C
Rolin, W. A., Carpet Dealer, 739 Market st L
Ronaldson, Chas. E., C. E., 4506 Pine st C
Roney, Chas. H.
Rorer, John, Surg. Inst. Maker L
Roscher, Ernest, Machinist, St. Louis, Mo C
Rosengarten, G. D., Chemist, 1532 Chestnut st L
Rosengarten, H. B., Mfr., 325 S. 17th st C
Rosengarten, M. G., 1815 Spruce st 1st
Rosengarten, Sam'l G., 1532 Chestnut st L
Rosenthal, John S., Spinner, 1713 N. 22d st C
Rothermel, J. G., Coal, 9th and Master sts 2d
Rowand, J. R., Physician, 1714 S. 6th st L
Rowbothom, Wm., Asst. Eng. U. S. N., 3225 Sansom st C
Rue, Sam'l, Machinist, 523 Cherry st C
Ruschenburger, W. S., W., Medical Director, U. S. N., 1932 Chestnut st L
Rutherford, William H., Chief Eng. U. S. N., 1503 Spruce st L
Ryan, Thomas, Merchant, 40 S. Wharves L
Ryan, Thomas, Machinist, 1732 Callowhill st C
Safford, Henry W., 125 N. 21st st L
Sailer, Frank, Salesman, 9th and Parrish sts C
Sailor, Henry, Marble Cutter, 10th and Vine sts L
Salmon, C. H., Manufacturer, Oxford and Hancock sts C
Sample, H. C., Philos. Inst. Maker C
Sandgran, C. C., Plumber, 347 Wharton st 2d
Sandgran, G. N., Plumber, 347, Wharton st 2d
Sanford, J. L., Real Estate, San Francisco, Cal C
Sanguinetti, P. A., Engineer, 3845 Warren st C
Sargent, J. H., Clergyman, 1220 N. 10th st C
Sargent, Wm. D., Sup't, S. W. 7th and Chestnut sts C
Sartain, Harriet Judd, Physician, 210 Franklin st 2d
Sartain, Henry, Plate Printer, 728 Sansom st L
Sartain, John, Engraver, 728 Sansom st L
Sartain, Sam'l, Engraver, 210 Franklin st L
Sartain, William, Artist, 728 Sansom st L
Sauerbrey, C. W., Mining Engineer, 226 S. 5th st C
Saul, Rev. James, D. D., 1630 Pine st L
Savery, C. C., Mfr., 247 S. 4th st C
Sawyer, Wm. H., Tel. Eng., A. D. Tel. Co., 3d and Dock sts C
Scattergood, Thos., Tanner and Currier, 278 N. Front st L
Schafer, J. C., Stone Cutter C
Schenck, Arch'd A., C.E., 4006 Balt av 2d
Schenkel, Geo. F., Machinist, 2437 N 9th st C
Schimmel, J O, Fruit Preserver, 431 Master st C
Schiveley, G. S., Physician, 1519 Centennial st C
Schmidt, Edward, Machinist, 315 Vine st C
Schober, F., Mech. Eng., 478 N 5th st C
Schutte, L., Engineer, 1645 N 10th st C
Schwarze, Aug., Merchant, 614 Arch st C
Schwenk, A. B., Student C
Scott, Charles, 1128 Arch st 1st
Scott, Franklin, Gents' Furn'ing, 814 Chestnut st C
Scott, G. W., Cooper, 1522 Moyamensing av 2d
Scott, Thos. A., President, 233 S 4th st 1st
Seal, Lewis, Merchant, 136 S 3d st L
See, Richard C., Merchant, 1501 Spring Garden st L
Seefeldt, W F, Musical Inst. M'f'r, 731 Race st C
Seiler, C., Dr. Mech., 1327 Spruce st C
Selden, Geo. S., Attorney, 1600 Master st C
Sellers, Coleman, Engineer, 1600 Hamilton st 2d
Sellers, Coleman, Jr., Machinist, 1600 Hamilton st 2d
Sellers, Jno., Upper Darby, Del. co, Pa L
Sellers, Jno, Jr, Machinist, 1600 Hamilton st L
Sellers, Sam'l, 611 Commerce st 2d
Sellers, Wm., Engineer, 1600 Hamilton st L
Semper, Conrad, Chemist, 232 Catharine st 2d
Seltzer, J. H., Superintendent, 2136 Market st C
Sewall, Basil, Agent, 713 Wood st 2d
Sexton, John W., Dry Goods Merchant, 112 S 3d st L
Seyber, Henry, 926 Walnut st L
Shain, Chas. J., Math Inst Maker, 716 Chestnut st C
Sharpless, Henry G., Merchant, 187 Arch st L
Sharpless, J. T., Physician, 1227 Arch st L
Sharpless, N. H., Lawyer, 28 N 7th st C

Sharpless, S. J., 705 Walnut st 1st & L
Sharpless, Wm. P., Merchant, 2513 Arch st L
Shaw, Alex., Hardware, 835 Market st C
Shaw, Elias J., Draughtsman, 1321 N 22d st 2d
Shaw, John Eyre, Attorney, 110 S 4th st C
Shaw, Louis, Druggist, 838 N 9th st C
Shaw, Nathan S., Stone Cutter, 1309 Heath st C
Shaw, Thomas, Machinist, 913 Ridge av C
Shea, Jas. S., Machinist, 1533 Thompson st C
Sheaff, John F., Coal Dealer, 220 S 4th st C
Sheble, R., Cabinet Maker, Bensalem P. O., Bucks co, Pa L
Shelmire, W N, Jr., Machinist, 1624 Ridge av C
Sheridan, John J., Druggist, 3d ab. Callowhill st C
Sheppard, Furman, Attorney, 717 Walnut st C
Shetzline, C. W., Carpenter, 314 Dickinson st 2d
Shewell, Walter, Machinist, 1418 Fairmount ave C
Shick, Wm., H. 1st
Shillingford, J. T., Merchant, 125 S 4th st C
Shinn, Jas. T., Druggist, Broad & Spruce sts L
Shinn, John, Machinist, 32 Merchants' Ex 2d
Shoemaker, B. H., Glass Warehouse, 205 N 4th st C
Shoemaker, G. Y., Wagon Builder, 1237 Spring Garden st C
Shoemaker, J., Publisher, 717 Market st 2d
Shoffner, W N, Bookkeeper, 1911 Hamilton st C
Shrigley, John M., Machinist, 2029 Callowhill st 1st
Sidle, J. W., Phil. Inst. Maker, 320 E Cumberland st C
Silver, J. S., Coal Merchant L
Simonin, Ch., T. A., 20 S Delaware ave C
Simons, G. W., Jeweler, 611 Sansom st 2d
Simons, H., Jr., Wheelwright L
Simons, M P, Photographer, 1320 Chestnut st L
Simpson, Thos, Calico Printer, 1522 Arch st C
Sinclair, Thos, Lithographer, 508 North st C
Sinclair, W. K., Clerk, 1912 Arch st C
Sinex, Thos., Merchantville, N. J. L
Singer, E. A., Teacher, 246 E Cumberland st 2d
Sloan, J., Farmer, Montgomery co, Pa L
Sloan, Samuel, Architect, 152 S 4th st C
Sloat, G. B., Manufacturer, Kensington L
Slocomb, S. A., Machinist, Farmers' Market C
Smedley, A. M., Carpenter, 807 N 20th st C
Smedley, Sam'l L., Chief Engineer and Surveyor, 224 S 5th st L
Smith, Albert H., Physician, 1419 Walnut st C
Smith, Benj., Accountant L
Smith, B. R., Broker, 4717 Main st, Germantown C
Smith, Charles B 1st
Smith, Chas. E., Engineer, 216 S 15th st L
Smith, Chas. W L
Smith, DeWitt W., 135 N 3d st C
Smith, Dillwyn, M.E., Burlington, N. J. C
Smith, Edwin, Machinist, 1600 Hamilton st 2d
Smith, E. M., Physician, 812 N 8th st L
Smith, Ephraim, Chemist, 1110 Pine st C
Smith, Geo. F., Dry Goods, 133 S 11th st L
Smith, H. W., 119 S Front st 2d
Smith, Isaac R., Merchant, 1016 Walnut st L
Smith, James Brown, 433 Arch st L
Smith, J. F., Civil Engineer. Reading, Pa. C
Smith, John, Machinist, 2331 Sepviva st C
Smith, J. Pancoast, 1923 Spruce st L
Smith, L. F., 2d
Smith, Randolph A., Bookkeeper, 1227 Parrish st C
Smith, R. Morris, Architect C
Smith, R. R., Lawyer, 733 Walnut st C
Smith, Samuel, Druggist L
Smith, Wm., Mech. Draughtsman, Front and Laurel sts C
Smith, Wm. Bugbee, Draughtsman C
Smith, Wm. H., Sugar Refiner, 427 Vine st C
Smith, W. H., Jr., Stationer, 620 N 7th st C
Smith, Wm. M., Machinist, 723 Jayne st C
Smyth, L., Sugar Refiner, 1420 Arch st L
Smyth, Wm C, Sugar Refiner, 921 N Broad st C
Snider, Geo., Bookbinder, 2311 Spring Garden st L
Snyder, Eliza C., Teacher, 1829 Chestnut st C
Snyder, Henry 1st
Snyder, M. B., Astronomer, 542 N 13th st C
Somerville, Jas. McA., M.D., 1714 Race st L
Soule, Richard H., Ass't Supt C
Spare, Benj. F., Carpenter and Builder, 344 N 15th st C
Sparks, Thomas W., Clerk, 121 Walnut st L
Speakman, Thomas S., 3326 Germantown av C
Speel, Joseph, Bookbinder, 25 N 7th st L
Spellier, Louis H., Watchmaker, Doylestown, Pa C
Spence, Jas., Steam Heating, 1108 Fairmount ave C
Spencer, J. A., Attorney-at-Law, 129 S 5th st C
Spittal, John, Wood Engraver, 409 Chestnut st L
Spon, E., Technologist, 442 Broome st, N.Y C
Sproat, H. Eric, Civ. Eng., 313 S 10th st C
Stabler, John, Commission, 501 Chestnut st C
Starr, Edwin P., S'type Founder, 324 Chestnut st C
Starr, Isaac, Merchant, 1417 Spruce st C
Starr, Samuel, Camden Iron Works, Camden, N.J. C
Starr, Thos. W., Type Founder, 324 Chestnut st C
Steel, Jas. W.. Engraver, 320 Walnut st C
Steinmetz, Adam, Steam Marble Works, 1029 Ridge ave C
Steinmetz, Chas., Bookkeeper, 1029 Ridge av C
Steinmetz, Howard, Marble, 1029 Ridge av C
Stelwagen, Jos., Paper Manufacturer, 525 Commerce st L
Stellwagon, Thos. C., D.D.S., A.M., 1627 Chestnut st C
Sterling, Andrew, 1607 S 2d st C
Stevenson, Wm. C., Jr., Drugs, 24 S 4th st 2d
Stewardson, John L
Stewart, Alexander, 224 S 5th st 2d
Stewart, Frank, Physician, 113 S 7th st L
Stewart, Harry, Draughtsman, 1600 Hamilton st C
Stewart, John L., Oil Refinery, 1148 S Broad st C
Stewart, Thomas S., Architect, 623 S 10th st 1st and L
Stockham, Chas., Jr., Lumber, 215 Cooper st, Camden, N J C
Stockton, Alex. D., Clerk, 510 N 4th st C
Storer, G W, Mech, Eng., 2010 Brandywine st C

Stout, A. M., Lawyer, 705 Sansom st C
Stout, Watson, Heaters and Ranges, 1216 Struthers st C
Stover, Lewis, Attorney, 522 Walnut st C
Straake, Frederick, Manufacturer, 20 N 5th st L
Stratton, Harrison D., Machinist, 146 N 11th st C
Stratton, Matthias, Gas Fitter, 719 Walnut st L
Stratton, Wm., Gas Fitter, 719 Walnut st L
Stratton, Wm. A., Grocer L
Strawn, Joel W., Chemist, 116 N Del av C
Strode, Joseph C., Hydraulic Engineer, Phila, Postoffice L
Strohm, Sam'l D., Dentist, 117 Laurel st C
Strong, W., Judge, Washington, D. C. C
Stroud, Wm. C., 2110 Mt. Vernon st 1st
Struthers, J. Strickland, Merchant, 313½ Walnut st L
Sturdivant, Horatio W., Engraver L
Sulgar, Abraham, Dry Goods L
Sumner, John, Blacksmith, 531 N 20th st 2d
Sunderland, Wm. C., Builder, 4215 Sansom st C
Suplee, N. R., Machinist, 1527 Arch st C
Supplee, Chas. D., Carpenter and Builder, 208 S 4th st C
Susholz, Geo., Cadet Eng'r, 1438 Camac st C
Sweatman, V. Clement, Accountant, 1508 Green st L
Sweetapple, Edward, Paper Maker, Elkton, Md C
Swerchesky, J. Gustavus, Physician, 121 Susquehanna ave C
Sykes, Joseph, Machinist, 1014 Shackamaxon st C
Sylvester, Louis, Mech. Eng., 1805 Walnut st C

Taber, George, Sec., 233 S 4th st L
Taggert, A. C., H. Eng., 1116 N Front st C
Taggart, Edward D., Agent, 104 N Del av C
Taggert, Wm., Mech. Engineer, 1103 Fairmount ave C
Talmage, Eben S., Bookbinder, 114 S 3d st C
Tasker, Thos. T., 1622 S 5th st L
Tasker, Thos. T., Jr, M't'r, 2020 Walnut st L
Tate, William J., Machinist, 410 N 12th st C
Tatham, Benjamin, Manufacturer, 82 Beekman st, N Y L
Tatham, Edward, 1114 Spruce st 1st
Tatham, George N., Manufacturer, 1114 Spruce st 2d
Tatham, Geo. N., Jr., 1114 Spruce st 1st
Tatham, Henry B., Jr., 226 S 5th st 1st
Tatham, James, 226 S 5th st 1st
Tatham, Wm. P., Manufacturer, 226 S 5th st 1st and L
Taylor, Frank H., Artist, 113 S 4th st C
Taylor, Geo. E., Tin Plate, 301 Branch st C
Taylor, George W., 50 N 4th st L
Taylor, Henry P., 648 N 10th st C
Taylor, John, 109 S Broad st C
Taylor, Stacey, House Carpenter, Grier st below 13th L
Teal, Chas. A., Machinist, 3029 Chestnut st C
Teal, Peter, Machinist, 12 Morgan st L
Tener, Rob't, Coal, 955 N Front st C
Tennent, John, Stock Maker, Mt Airy L
Tetlow, Henry, Toilet Soaps, 122 Arch st C
Tetlow, J. K., Type Founder, 1523 N 13th st C
Thackera, B., Manufacturer, 718 Chestnut st C
Thomas, A. W., Manufacturer C
Thomas, J. V., Iron Master, Bellefort, Pa L
Thomas, Lancaster, Apothecary, Broad and Ellsworth sts C
Thomas, Pliny, Locksmith, 17th ab Arch st C
Thomas, Reynold, Clerk, 304 Walnut st C
Thomas, Samuel A., Gas Engineer, 420 N 11th st C
Thomas, Theodore, 2019 Delancey st 2d
Thompson, Ambrose W L
Thompson, David 1st
Thompson, E. O., Tailor, 908 Walnut st C
Thompson, Franklin A., Heaters and Ranges, 137 N 10th st C
Thompson, Geo., Manuf., 900 Pine st L
Thompson, John J., 2024 Spruce st 1st & L
Thompson, J. P., Merchant, 609 Market st C
Thompson, Thomas, Stone Cutter, 1227 Spring Garden st L
Thompson, Wm. J 1st
Thomson, E., Chemist, 2134 Fitzwater st C
Thorn, Fred. G., Architect, 233 S 4th st C
Thorne, Wm. H., Machinist, 21st above Market st 2d
Thurston, Rob't H., Prof. Mech. Engineering, Stevens Institute, Hoboken, N J C
Tilghman, B. C. Lawyer, 1114 Girard st L
Tilghman, Edward 1st
Tilghman, Rich'd A., 321 S 11th st 1st & L
Tilter, Samuel, Copper Plate Printer, 815 N 15th st L
Todd, Wm. E., Machinist, 1365 Beach st C
Todd, Wm. H., Lawyer, 704 Walnut st C
Toland, Geo. W., 2039 Pine st L
Torr. J. Nelson, Printer, 110 S. 3d st C
Towne, Henry R., Stamford, Conn. 1st
Townsend, E. Y., 218 S 4th st 1st
Townsend, I., Manufacturer, 329 N 11th st C
Tracy, E., Watch Case Maker, 104 S 6th st L
Tracy, Miles S., Brass Founder, 625 Summer st C
Trainer, W. E., Cotton Manuf., Linwood, Del. co., Pa. C
Trautwine, J. C., Civil Engineer, 530 N. 6th st L
Trautwine, John C., Jr., Clerk, 1608 Market st C
Travis, J. L., Brass Works, 241 Arch st C
Tray, William, 2029 Callowhill st C
Trego, Chas. B., Teacher L
Troth, Saml'l N., Physician, S. W. 7th & Thompson sts 2d
Trotter, George, 218 S. 4th st 1st
Trotter Wm. H., Merchant, 36 N. Front st C
Truitt, Jo . P., Wool Manufacturer, Hancock and Oxford sts C
Trueman, Wm. H., Dentist, 511 Spruce st C
Truman, Alex. S., Hardware, 835 Market st C
Truran, John, Draughtsman, 13th and Spring Garden sts 2d
Tucker, Christopher, 1141 N. 17th st C
Turnbull, C. S., Physician, 1220 Walnut st C
Turnbull, Lawrence, Physician, 1208 Spruce st L
Turner, Ernest, Surveyor, 141 N. 20th st 1st
Turnpenny, Jos. C., Druggist, 813 Spruce st L
Tweedale, Thomas, Moulder, 522 N. 6th st C
Tyndale, Robinson, Clerk, 707 Chestnut st C

Uhlinger, W. P., Machinist, 22 E. Canal st C

Ulmer, Levi B., 1620 Swain st 2d
Unger, Herman, Draughtsman, 409 E. Girard av C
Unger, John F., Civil Eng., 431 Master st C
Ustick, Stephen, Machinist, 131 S. 4th st C

Vail, Hugh D., 1927 Mt. Vernon st 2d
Van Artsdalen, Jas. T., Engraver L
Vance, James M., Hardware, 1629 Girard av L
Van Horn, Ed. D., Brush Manuf, 1009 Arch st C
Vanhorne, M. K., Carver, 186 S. 11th st L
Vaux, George, 1715 Arch st C
Vaux, Wm. S., 1702 Arch st L
Veale, Moses, Attorney, 102 Walnut st C
Verree, J. P., Manufacturer, 939 N. Del. av C
Ver Kouteren, A. Y., Dr'tsman, 503 N. 20th C
Van Haagen, A., Soaps, 2518 Callowhill st C
Van Haagen, C., Machinist, 2518 Callowhill st C

Wagner, H. D., Mech. Eng'r, 1819 Spruce st C
Wagner, Wm., 17th and Montgomery av L
Wahl, Wm. H., Chemist, 1436 N. 13th st 2d
Waitt, Geo. W., Merchant, Chestnut Hill C
Walanta, Edmund, 1616 Sydenham st 2d
Walborn, Cornelius A., Middleton, Pa. L
Walder, John H., Mechanical Engineer, Germantown, Pa. L
Walker, Abraham, Wagon Builder, 20th and Filbert sts C
Walmsley, W. H., Merchant, 924 Chestnut st C
Walsh, Moses, Chemist, 9th and Parrish sts C
Walther, Fred'k, Optician, 703 Thompson st C
Walton, C., Hardware Dealer, 625 Market st C
Walton, W. K., Manufacturer, 262 S. 2d st C
Wallace, John Wm., 728 Spruce st C
Walter, Thos. U., Architect, 720 N. Broad st L
Walton, C. W., Manufacturer, 413 Arch st C
Wanich, Alex., Machinist, 1410 Hanover st 2d
Ward, Chas, Engineer, 268 S 9th st C
Ward, G M, Physician, 268 S 9th st C
Warder, J H, Engineer, Indianapolis, Ind L
Wardle, Thomas, 465 Arch st L
Warne, Kenton, Clerk, First Nat. Bank, Phila C
Warner, Cuthbert, Instrument Maker, 2327 Fairhill st C
Warren, E. B., Roofer, 1013 Spruce st C
Warren, Samuel D., Merchant, 17 State st., Boston, Mass. L
Warrington, James, Merchant, Camden, N.J. L
Waters, Chas., Machinist, 8 Province st., Boston, Mass. C
Watson, Andrew, Machinist, 538 E Cumberland st C
Watson, Jas., Machinist, 1608 S Front st 2d
Watts, Geo. W., Draughtsman, 1057 Richmond st 2d
Weaver, John J., Plumber, 7th and Filbert st C
Webb, S. Wm. F., Clerk, 16 Logan Square. L
Webster, E. C., Teller, Camden, N. J. C
Webster, John T., Designer, 3504 Fairview st C
Wehn, Geo. H., Artificial Stone, 911 Filbert st C
Weidner, Chas. A., Chester, Pa 2d
Weightman, Wm., Chemist, 9th and Parrish st L
Weigley, W. W., Attorney, 702 Chestnut st C
Weigner, J B, Carpenter, 1033 Lawrence st 2d
Weir, W. B., Notary, 3936 Chestnut st C
Weimer, P. S., Engineer, Lebanon, Pa 2d
Weldin, Lewis C., Student, 1101 Spring Garden st C
Welsh, Ashbel, C.E., Lambertsville, N. J. L
Welsh, Chas., Engraver, 1617 Mt. Vernon st L
Welsh, John, Merchant, 1031 Spruce st 1st & L
Welsh, Samuel, 304 Walnut st 1st
Welsh, Wm, Merchant, 1122 Spruce st 1st & L
Wernicke, A. C., Teacher, 219 N 16th st C
Wernwag, Wm., Baker. L
West, Edgar C., Bookkeeper, 1211 Mt. Vernon st C
West, Edwin, Bookkeeper, 1015 N Del. av C
West, Henry F., Mfr., Gloucester, N. J. C
West, John, Mechanical Engineer, Bethlehem, Pa L
West, Thos., Smelter, 212 E Thompson st C
Westinghouse, Geo. Jr., Pittsburgh, Pa. 1st
Weston, H. James, Engineer C
Wetherill, Robt., Machinist, Chester, Pa 1st
Wetherill, Thos., 1529 Locust st C
Weymer, W. Norris, 1002 Arch st 2d
Wharton, B. B. H., Chief Engineer U. S. N., 1506 Spruce st C
Wharton, Jos., Nickel Works, 125 S 12th st C
Wharton, Jos. S. L., Iron Founder, 15th and Wood sts C
Wharton, Wm. Jr., R. R. Builder, 1506 Pine st C
Whartenby, Thos. L
Wheeler, Elbridge, Inventor, Saunders av., W. Phila. C
Wheeler, Jos. K., 2026 Chestnut st L
Whelan, Chas. S., 309 Walnut st 2d
White, Chas. H., Cabinet Maker, 723 S 10th st L
White, Dr. C. A., Dentist, 235 N. 10th st C
White, Duncan, Mfr., Norristown Pa. C
White, Geo. H., Engr. U.S. N., 906 Spruce st C
White, Henry J., Heaters and Ranges, 21 S 7th st C
White, Sam'l S., Mfg. Dentist, 12th and Chestnut st 1st & L.
Whitney, Geo., Engineer, 16th and Callowhill sts L
Whitney, Jas. S., Mfr., 16th and Callowhill st L
Whitney, Jno. R., Mfr., 16th and Callowhill st L
Whitney, Thos. J., Sewing Mach, 1530 N 17th C
Wickersham, C., Attorney at Law, 124 S 6th st L
Wickersham, Morris S., 247 S. 3d st L
Wiedersheim, John A., Patent Solicitor, 110 S. 4th st C
Wiegand, John B., 1033 Lawrence st 2d
Wiegand, Jno., Prest., 1000 Walnut st 1st & L
Wiegand, Jno. Jr., 45th st & Osage av L
Wiegand, S. Lloyd, Engineer, 124 S. 6th st. L
Wiegand, Thos. S., Apothecary, 528 Arch st C
Wiemer, P. L., Lebanon, Pa 2d
Wilbraham, J. W., Sr., Machinist, 2316 Frankford road
Wilbraham, J. W., Jr., Machinist, 720 E. Cumberland st C
Wilcocks, A., Physician, 2133 Walnut st 2d
Wilcox, Austin O., cor. Broad and Parrish sts L
Wild, Chas E, Sup't Print Works, Chester, Pa C
Wildberger, P. J., Manuf., 814 Vine st C
Wildman, E. D., Architect, 506 Walnut st C
Wilder, Hans M., Druggist, N.W. 4th and Wood sts C

Wiler, Wm., 225 S 5th st 2d
Wiley, Jos., Druggist, 154 N 3d st C
Wilford, Jno. B., Draughtsman, 1506 N 22d st C
Wilhelm, Chas., Lamp Maker, 919 Race st L
Willard, D. D., Iron Mfr., 1724 Spruce st C
Willcox, Jos. C
Williams, Henry J., Attorney, 712 Walnut st L
Williams, Albert B., C.E., 617 Franklin st C
Williams, Chas., Heaters and Ranges, 1132 Market st C
Williams, Chas. B. L
Williams, Chas. B., Merchant, 611 Market st C
Williams, C. D., Salesman, 224 S. 11th st C
Williams, Edward H., 500 N Broad st C
Williams, Geo. W., Machinist C
Williams, Isaac S., Tin Plate Worker, 728 Market st C
Williams, N. W., Engineer, 710 N 10th st C
Williamson, Jno., Lumber Merchant, 45th and Lancaster av. L
Williamson, Wm. C., Engineer, Richmond and York sts C
Willitts, Alfred, Furniture, Holmesburg, Pa. L
Willits, Jas., Bricklayer, 1629 Mt. Vernon st L
Willits, T., Merchant, 152 N. 4th st C
Wills, E. S., Carpenter C
Willson, J. A., M'f'g Optician, Reading, Pa C
Wilson, C. G., Hardware, 508 Commerce st 2d
Wilson, C. R., C. Eng. 225 S. 6th st C
Wilson, E. H., Clerk, 1500 Green st 2d
Wilson, E. L., Publisher, S.W. 7th & Cherry. 2d
Wilson, H. A., 512 Marshall st 1st
Wilson, H. H., 512 Marshall st 1st
Wilson, J. A., Civ. Eng. 410 Walnut st L
Wilson, J. L., Civil Eng., 512 Marshall st 1st
Wilson, Jos. M., Chief Eng. 410 Walnut st L
Wilson, J. M., Salesman, 338 S. 15th st C
Wilson, O. H., Merchant, 215 N. Water st L
Wilson, W., Manufacturer Paper Hangings, 18th and Washington av C
Wilson, W. C., Paints, 105 S. Front st 2d
Wilson, W. H., Civil Eng., 233 S. 4th st L
Wiltberger, H. A., Bookkeeper 3947 Market st L
Windrim, Jas. H., 219 S. 6th st 1st
Winebreiner, David. L
Winebrener, T. E., 1409 Walnut st C
Winsor, H., Merchant, 338 S Delaware av C
Winsor, W. D., Merchant, 338 S. Delaware av C
Wise, John, Aeronaut, 1951 N. 11th st C
Wise, Saml. C., Carpenter, 220 McAlpine st C
Wolf, T. R., Ph. D. Chemist, Newark, Del. C
Womrath, F. K., Furrier, 710 Arch st C
Wood, A., Iron Manufacturer 1525 Arch st L
Wood, A. Jr., Conshohocken, Pa. L
Wood, George R., 218 S. 4th st 1st
Wood, H. C., Merchant, 612 Race st L
Wood, H., Manufacturer, Conshohoken, Pa. L
Wood, J. T., 8th and Cherry, Camden. 2d
Wood, Robt., Ornamental Iron, 1136 Ridge av L
Wood, T., Manufacturer, 1836 Green st L
Wood, T., Machinist, 2106 Wood st C
Wood, W., Manufacturer, 400 Chestnut st 1st
Wood, W. W. W., Eng. in Chief. U. S. N., 108 Walnut st L
Woodbridge, J. E., Draughtsman, Chester, Pa. C
Woodruff, G. J., Machine Works, Norristown Pa C
Woodruff, T. T., Machinist, Norristown, Pa. C
Woods, J., Nashville, Tenn. L
Workman, H. Weir, Broker, 123 Walnut st C
Worrall, A., C.E., 627 Wood st C
Worthington, H. W., Bookkeeper, 449 N. 5th st C
Wright, J. H., Teller, 34 S. 3d st C
Wright, J. K., Oil Silk Mfr. 2322 Green st L
Wright S., Machinist C
Wright, W. R., Draughtsman, 531 N. 22d st C
Wyand, Daniel, Shoemaker, 1207 Pine st C
Wyckoff, E S, Physician, 6th and Arch sts C

Yarnall, Hibbert, Builder, 21 N 7th st C
Yeager, Jno. C. L
Yeager, John E, Stair Builder, 1415 Vine st C
Yost, Thomas W, Merchant, 28 N 9th st C
Young, George, 515 Pine st 2d
Young, Lewis T, Salesman, 700 Passyunk av. C
Young, Richard, Distiller, Morton Del Co, Pa L
Young, S. H. 2d

Zentmayer, Chas., Optician, 147 S. 4th st C
Zentmayer, Jos., Optician, 147 S. 4th st C
Ziegler, George J., M.D., 128 S. 15th st L
Zimmerling, C., Sugar Refiner C
Zoellner, Jos., Doctor, 342 N. 5th st 2d
Zorns, Chalkley, Milk Dealer, 1409 Frankford st C

Number of Contributing Members,	- - - - - - - -	1063
" of Life "	- - - - - - - - -	506
" of 1st Class Stock "	- - - - - - - -	444
" of 2d " " "	- - - - - - - - -	178
Total,	- - - - - - - - -	2191

… JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. CIII. JANUARY, 1877. No. 1.

EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Motive Power of the International Exhibition.—In another place in this number of the JOURNAL, will be found some strictures on the views expressed in the editorial of December, as to the course of the Commissioners in attempting to substitute for the prizes for prominent or acknowledged excellence, usually distributed at the great Exhibitions, a system of awards, founded upon some universal standard of mediocrity ("based on inherent and comparative merit,") judiciously qualified by numerous adjectives. The remarks of our correspondent carry with themselves their own inferences, and, it seems to the editor, sustain fully the conclusions of the editorial, which has only to be read over again to support itself. The point made as to the alleged "award of prizes to all," will scarcely hold when its qualification is recognized, that the "expectation, that the examination of the judges would bring out the most striking novelties, was frustrated by awarding prizes to all" [novel-

ties]. The anticipation that the power of permutation of adjectives might be exhausted in the 700 favorable reports on art subjects, is quite pleasant to entertain, or at least is entertaining to suppose, and the assurance that some weeks yet must pass before the 13,000 pages, paragraphs, sentences, of laudation will be published, is a relief in some regards. The pursuit of knowledge under difficulties would be exemplified in the perusal of this threatened series of volumes—the trial of "patience" is evidently yet to come.

Returning to the exhibition, this want of guidance from the hands of authorized and competent judges is seriously felt in any effort to appreciate its teachings; even an expression of opinion in favor of one or the other exhibit becomes almost imprudent, and the publication of any one of the 13,000 laudations is an admission of its claims to be the "highest prize." Yet it may be worth while to take a short retrospect, and note what steps of progress, if any, have been made apparent in 1876.

The great source of power to-day is the steam boiler and engine. In the steam boiler exhibits it cannot be claimed that much, that was new since the Vienna exhibition, was shown. The chief noteworthy examples were clearly those of Corliss and of Galloway. The Corliss example was that of an arrangement of a number of *externally-*fired-upright-tubular boilers, which, although they are not new ones, are of comparative rarity, and at least novel to most steam engineers; some of the attachments, at all events, were different from common, and the boiler itself presents much facility of construction and of grouping of a number together. The removal of tubes from the zone in the middle of the circle, making a clear water space on an *equatorial* line, so as to admit a free circulation downwards of the return water, after giving up its steam, and also providing access to the tubes on the inside of the boiler for scaling or cleaning, make this boiler a safe one, and one likely to give dry steam. In short, this specimen is likely to add one to the number of approved and accepted forms of the steam boiler of the future, in which the details will be made to pass through the whole train of well known modifications, and possibly be patented as new combinations.

The Galloway boilers were remarkable to American practice as specimens of the Lancashire boiler, which has such an extensive use for the free burning coals of England, as to form a type of national construction. It is expected to give the readers of the JOURNAL a fuller description of the Lancashire boiler at some early day, for

its details present many valuable points for comparison with American practice. The patentable feature of the Galloway exhibit is well known to all engineering readers and this example really attracted much attention. The efficiency for steam-making of the Galloway surface, the ease with which it is cleaned, internally to the flue, or externally to the water space, the satisfactory circulation of water within the boiler, and consequent uniformity of water-level and dryness of steam, were as evident facts from an inspection of the boiler, as they became after a *test.* Either the Corliss or the Galloway boiler will carry sufficient water to meet the demands of varying power or heating capacity without great impairment or wasteful increase of pressure.

The locomotive boilers, in the best forms, were well represented in the various locomotive engines on exhibition, but it cannot be recalled by the writer, that any striking novelty was presented. The boilers of the various steam fire engines were of the usual anomalous construction, and were adapted solely to their specific uses. These specimens of boiler practice with the least of water—generally without a water line—form a singular type of their own, but they will more properly be classed, rather as part of the steam fire engine than as an independent adjunct. Possibly the most extraordinary *boiler* (?) was that of the steam baking apparatus of Perkins, of London, where each tube was sealed by welding up both ends, enclosing a small quantity of water (18 inches in length out of 12 or 14 feet of tube), the air being expelled by boiling the water before welding up the last end; a short end of each of these tubes is exposed to the fire, the collection of tubes forming a fire-box; while the rest of the tube, 10 or 12 feet long, is projected into the oven, the collection of tubes forming the bottom, sides and top of the same. The circulation of steam in these tubes (boilers) is perfect, a slight elevation of the outer end sufficing to allow the condensed water to return towards the fire, while a temperature of 350° to 400° is attained in the oven successfully. There were no examples of any marine boilers, and the Scotch high-pressure marine did not have any exemplar on the ground, nor is it remembered that any models or drawings of this yet novel, but exceedingly valuable, boiler were presented. It should be borne in mind that this Scotch boiler gives an evaporative effect, with dry steam, scarcely equaled by any other, and greatly surpassing the ordinary water tube boilers of patent rivalry and tests, as in fact do most of the accepted types of boilers of usual construction.

As to the other boilers of the Exhibition—are not their records written in the patent office, and will not their merits be set forth in the reports which some weeks hence will demonstrate? It would have been satisfactory to have had one good setting of the ordinary American externally-fired-horizontal-tubular boiler, which now represents about three-fourths the number of stationary boilers in use in this country—a boiler whose duration, economy in prime cost, efficiency as a producer of steam from any fuel; and, above all, whose safety from disastrous accident is second to no other type of known existence. With thirty years' experience, the writer has never known of an accident, which could be called a disaster, with the plain horizontal-underfired-tubular boiler.

The prominent steam engine of the Exhibition was, of course, that of Corliss, whose name is associated with the use of the trip by means of a governor for closing a steam slide valve. It cannot be claimed that this exhibition had the surprise of novelty, for thirty years of persistence has brought this type of engine into recognition as the Corliss engine over all the world, and this particular example is simply a large specimen, with some very ingenious, but not very important, novelties of detail. The most valuable lesson to American millwrights was in the use of cut gearing on so large a scale. The general use of belting in this country, has misled many to the supposition that such use is preferable in all cases to that of gearing, while the truth is that for continuous transmission of a given force, the gear wheel and line of shaft are more economical in wear and in consumption of power. Blowing engines, pumping engines, winding engines, sugar mill engines, and numerous engines for power alone, competed for notice and acknowledgment, but the writer is compelled to say that his most diligent search failed to discover in any of them what would be a marked step in the progress of the steam engine since the Vienna Exhibition. It would be well to publish the details of the American Bull pumping engines, of which there was one example of a type now well fixed and established. The modification of the Cornish valve gear is very peculiar and very effective.

The real step in advance was probably attained in the Davey differential valve movement which was exhibited in the English department. This novelty has been noticed in the JOURNAL, Vol. CII, p. 121, and is unquestionably the most marked improvement in the Cornish or Hornblower engine for a hundred years. The complication of parts, although each was simple in itself, which characterized all

the valve movements of the non-rotative engine from the time of the elder Hornblower, 1720, to the present multiplicity of makers of steam pumps, has disappeared before this means of regulation. Its greatest recommendation is its *safety* provision in preventing injury to the working parts, in case of breakage of pipes, or other accident affecting the constancy of labor of the engine. A reference to another adaptation of this valve movement will be found on the pages of this number of the JOURNAL.

The Otto & Langen explosion engine presents much of novelty. It is unquestionably a recent application of heat-force, but having passed through two previous great exhibitions, it is consequently not entitled to the highest prize. For American practice, however, it is entirely new. Unfortunately it has very restricted limits of dimension, probably it cannot be used with prudence in transmitting, to exceed two horse-power force from any one engine, and for larger demands it quickly becomes altogether impracticable. It is *the* most perfect heat motor ever made, even excepting the gunpowder pile driver, which has the same element of mechanical application. A full description of this engine was given in the JOURNAL, Vol. C, p. 262. The three-cylinder Brotherhood engine, which has met with so large development in England, was represented by a working example in the Brewers' department, but not, it is thought, in any conspicuous manner elsewhere.[1] This engine which has never been offered at any previous great exhibition, promises to form a type of a future class of working steam engines of extensive applicability to special uses.

Marine engines found an admirable example of the right angle crank-Elder-Cowper engine of the most recent form in the exhibit of Messrs. Cramp, of Philadelphia. [The construction of this class of engine without the cumbersome slide valve and ponderous valve movements, by adoption of the balanced poppet or lantern valves, would seem to be possible after our American experience in such valves, for single cylinder engines.] The U. S. exhibit also contained a navy horizontal compound engine of much merit.

In American engines a foremost place should have been given to those of the paddle-wheel steamers of our internal navigation. The

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[1] Since writing the above the writer's attention has been called to the fact that the "three-cylinder engine" formed a part of the exhibit of Messrs. Wm. Sellers & Co., as appears in a very obscure way in that not exceedingly satisfactory publication, the "U. S. Centennial Commission Official Catalogue."

largest steam engines running in the world are those on the Sound steamers from New York. For elaboration of finish, permanency in service, economy in the use of steam, these engines rank among the best. They are the exponents of a class, whose details of construction, and relations of movement of parts, have been established by over fifty years of experience of our most able and competent mechanics and engineers. Any one of them may be taken as a display of perfected mechanism. Their polished side pipes and steam chests, surfaces of silver and golden brightness, often more than a hundred square feet in extent, represent at once both the care taken of the engine, its economy in preserving the heat, and the appreciation of its permanent value when first built. These engines were represented by a small, and generally unnoticed, working model in the exhibit of the Morgan iron works of N.Y. (now John Roach, Chester, Pa.), of the engine of the Bristol steamer, Erastus W. Smith, engineer. Mr. Smith has been the designer or director in construction of most of the larger engines of this character for nearly thirty years. The variable cutting off of steam by tripping the valve each stroke, was attached to engines of this type over thirty years ago, by Sickels; and, with improved details, the Sickels cut-off yet holds its place in their construction. Sickels was the first to propose tripping the steam valve by means of the governor, and patented the application to the poppet valve some years before Corliss perfected a similar application to a slide valve. There was an exhibit of Sickels' models, showing his connection with the growth of the steam engine, which, in the interest of history, ought to be described by some competent writer in the records of this exhibition.

There was a signal omission in the failure to exhibit any specimen, model or drawing of the engines of our western river steamers. Possessing an importance in internal navigation, in the industry of our country, second only to that of the locomotive engine, these steamboat engines of great practical merit, wonderful simplicity, never ending durability, only equaled in this regard by the old pumping engines of Great Britain, were overlooked in *our* national Exhibition. There is no engine so instructive to the schemer on refinements, as the western river engine, and it has great capabilities for economy which are sometimes availed of in the most surprising way.

The locomotive engines were numerously represented, but many of our best makers did not send specimens of their construction; still there was a fair exhibit of the American type of engine on approved

models. It cannot be said that any one of them will be accepted as the engine of the future, or as presenting a type of novelty which shall divert the present practice in any one positive direction. Increase of weight to the degree of excess, perhaps, was the most marked change of the past five years in America. No foreign locomotives were offered in competition, and opinions differ greatly as to the merits of American and European locomotive building, until dispassionate comparison is almost impossible.

The traction and farm engines are beyond the expression of any opinion by the writer, who is free to say that unless his attention was called to specific details of such engines, his want of knowledge of their uses would preclude any judicial view. It may be that the *full* reports of the judges in this group will allow "Americans" to make up their minds as to relative merits; but it is doubtful if many of these will, and certain to the mind of the writer, that most exhibitors will be disappointed in the transferring of the right to judge from the competent judges to an unconcerned public.

It is in the field of comparison of numerous exhibits of one class, that the reports of the judges will, if devoted to description and *avoiding* commendation, possess the highest value. The casual observer, no matter how critical, and even the examiner, no matter how careful, would fail altogether to detect differences or merits, or defects, in the absence of full explanation. One engine was as like another as peas in the same peck measure—criticism fails where appreciation cannot be had. The requirement of a certain order and standard size of illustration, together with some description, such as would enable a competent workman to know how to use the engine, similar to the demands of the Patent Office, might have eliminated some of the difficulties of examination by visitors and by judges.

Instruction at the Franklin Institute.—A course of instruction by Hugo Bilgram, M.E., under the auspices of the Institute, will be given in 12 lessons on the slide valve, on the successive Saturday evenings, commencing January 6th, 1877. Tickets for course, $2.50.

The third course on Phonetic Shorthand, by D. S. Holman, Actuary of the Institute, will commence January 8th; tickets for this course of 12 lessons, $3.00. The previous two courses on this subject have been crowded by scholars, and this class is already filled.

Franklin Institute.

HALL OF THE INSTITUTE, Dec. 20th, 1876.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 119 members and 7 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting 19 persons were elected members of the Institute, and the following donations were made to the library:

Thirty-second Annual Report of the American Institute of the City of New York, for the year 1871–72. Albany, 1872. From Wm. P. Tatham.

Blank forms used by U. S. Centennial Commission, from 1 to 210. From P. C. De Sangue, Philadelphia.

Catalogue of the Reproductions of Art Metal Works in the South Kensington Museum, London.

Descriptive Essay of Elkinton & Co.'s exhibit at the International Exhibition of Philadelphia, 1876. From the Hon. Com. of Education.

(To be continued in next number.)

The following Report of the chairman of the Centennial Reception Committee, presented to the Board at its last meeting, was also read:

Philadelphia, Dec. 13th, 1876.

Report of the Centennial Reception Committee to the President and Members of the Franklin Institute:

Gentlemen:—Your Committee, appointed to take charge of the reception room in Machinery Hall, was so subdivided that each member of the committee was expected to attend in the room once a month. The visitors registered their names on entering, and our reception book contains the names and addresses of three thousand and seventy-nine visitors, coming from all parts of the world, from Japan to Russia, many of them being the official representatives of great distinction in their own land. The largest mumber of visitors was one hundred, on September 28th, "Pennsylvania Day."

The room answered an admirable purpose as a rendezvous for parties interested in the mechanic arts, both at home and abroad, and we believe it has been of great use in popularizing the Institute

and making it better known. The models of interesting machines on exhibition, attracted great attention, and we feel under great obligations to the publishers of the various mechanical and scientific journals, both at home and abroad, for the prompt manner in which they furnished their periodicals, our tables being kept supplied during six months, without expense to the Institute.

We are also under obligations to Mr. Isaac Williams, for the use of a water cooler, and to Geo. W. Childs, Esq., for six months' use of the *Ledger*. Respectfully submitted by

J. E. Mitchell, *Chairman.*

The Secretary presented his report, embracing John Selter's model of an atmospheric engine; Radde's underground telegraph; a calculating machine invented by Geo. B. Grant; a mowing machine embodying a new mechanical movement, by Wm. Farr Goodwin, and a mechanical horse by the same inventor.

The following letter was read:

Frankford P. O., December 11th, 1876.

Dear Sir.—I have just come in possession of a very fine bust of my deceased father, John Struthers, an old friend of yours, and for many years one of the officers of the Franklin Institute.

The bust is of pure white marble, executed by Canova. Desiring that the Institute should become the custodian of the same if it should be approved by the Board of Managers, I have taken permission to address you, requesting that you would be pleased to make known to the gentlemen officers of the Institute my desire, and kindly requesting a reply at your convenience.

Yours, very respectfully,

John S. Struthers.

To Frederick Fraley.

The Secretary stated that the records of the Institute show that Mr. John Struthers was one of its founders, his membership number being 16, and that he was a member of the Board of Managers continuously from 1827 to 1849.

The following resolution, offered by Mr. Fraley through the Secretary, was unanimously adopted:

Resolved, That the offer of Mr. John Struthers to make the Institute the custodian of the marble bust, by Canova, of his father, the late John Struthers, be and the same is hereby cordially accepted, and that the Board of Managers be requested to make such arrangements as may be needed to receive and care for the said bust.

Mr. S. Lloyd Wiegand offered a resolution, which was amended to read as follows:

Resolved, That the Board of Managers be hereby requested to procure the use for the Institute, an efficient testing machine for testing the strength of materials, when such machine is wanted by the Institute; such machine to be selected by a Committee appointed by the Chairman of the Committee on Sciences of the Arts.

On motion the resolution as amended was adopted.

Mr. Hector Orr, vice-president of the Meteorological Section, made a verbal report that at the meeting held on the 4th instant, a resolution was adopted dissolving the Section, in consequence of "failure of sufficient interest in the Section to maintain the organization."

The President announced, that in accordance with the By-Laws of the Institute, nominations for officers to be elected at the annual meeting in January next, are to be made at this meeting; and that nominations for President, Secretary and Treasurer, to serve one year; one Vice-President, eight Managers and one Auditor, to serve three years, are now in order. The following members were then placed in nomination:

For President, Dr. Robt. E. Rogers.
For Vice-President, Henry G. Morris.
For Secretary, J. B. Knight.
For Treasurer, Frederick Fraley.
For Managers, Prof. Edwin J. Houston, Enoch Lewis, C. H. Banes, Wm. Helme, Saml. Sartain, Dr. C. M. Cresson, Chas. Bullock, Richard McCambridge, H. L. Lipman, Alex. Purves, Mark Balderson, W. Barnett LeVan, Jas. H. Collins, Abram W. Haines, John Sartain, C. Chabot, and W. L. Dubois (declined).
For Auditor, Wm. Biddle.
For one Representative of the Institute in the Board of Trustees of the Pennsylvania Museum and School of Industrial Art,
J. E. Mitchell and J. B. Knight.

On motion, it was

Resolved, That the Secretary be directed to send with the notices of the Meeting in January, a printed list of nominations, giving the occupation and address of each person, and what number is to be elected. The nominations for a representative to the "Museum," to be sent on a separate piece of paper.

The President appointed the following members to act as tellers at the annual election to be held on Jan. 17, 1877: Wm. A. Rollin, W. L. Dubois, Wm. Taggart, John Canby, Geo. Gardom, J. C. Trautwine, Jr., Chas. S. Close.

The Secretary announced that the second quarter of the drawing school would open on Monday, Jan. 8th, 1877, under the direction of Prof. L. M. Haupt; and that the class in phonetic shorthand had been very successful, and that its second quarter will begin on the same date, in the lecture room of the Institute.

On motion, the meeting adjourned.

J. B. KNIGHT, *Secretary.*

Diatoms in Wheat Straw.—In the article on infusorial earth and its uses, published in the last number of the JOURNAL (vol. CII, pp. 407–422), there is a quotation from a report made by Prof. P. B. Wilson, of Washington University of Baltimore, Md., accompanied with a plate of "Forms of Diatoms (alleged to have been) found in Col. Kunkel's straw." From the *Journal of Microscopy*, of August, 1876, it appears quite certain that Prof. Wilson was in error in announcing his *find*, and has permitted himself, either willingly or otherwise, to become an agent in advancing the interests of some fertilizer patent. The *Journal of Microscopy* says: "We have submitted an impression of the engraving accompanying Prof. Wilson's article, to one of our ablest diatomists, and requested him to note for us the names of the 'some thirty-six forms of the diatomaceæ, which he (Prof. Wilson) has carefully sketched.'" The reply enumerates at length a number of marine and fresh water diatoms, sponge spicules, a little of the siliceous cuticle of the straw, and a foraminifer; naming all but five objects, which are left in doubt. "Only one form belongs to the Virginian deposit, with which Kunkel's field was fertilized (?), and which is exclusively marine!"

The *Journal of Microscopy* says further: "Bearing in mind that these organisms, as figured, have been obtained by destroying the organic matter with nitric acid, we find *Bacillaria* figured as it exists only in the living condition—the frustules being joined together in the peculiar way which has given to this form the specific name *paradoxa!!!* For this diatom to have passed through a bath of nitric acid, and come out in the condition figured, would have been almost as great a miracle as the passing of Shadrach, Meshach and Abed-nego unscathed through the fiery furnace of Nebuchadnezzar. So, too, we find a *calcareous* foraminifer figured under the same circumstances! Verily this *is* such a view as has not 'fallen to the lot' of ordinary microscopists to behold—either in twenty, or in

four times twenty years. After such instances, the numerous minor features which are utterly irreconcilable with facts, and which are found in this plate, may be safely passed over."

A close reading of the article of Doctor Wahl will make it evident that he qualifies his belief, and only quotes, with comments, the statements of Professor Wilson; but a more thorough knowledge of the subject of microscopy on the part of the doctor, or on the part of the editor of this JOURNAL, would have avoided the publication of this piece of doubtful science. A previous article by Prof. Wilson appeared in the *American Journal of Science*, for June, 1876. In the September number of the same journal the editors assert that Prof. Wilson was mistaken in the real nature of the objects he examined.

The Davey Movement for Valves of Pumping Engines. —There will be found in a late number of *Engineering* (Nov. 17, 1876), one of the most recent applications of this valve-movement, proposed for a compound engine of the largest class, for use in a silver mine in Nevada. The reader is referred to the description and drawings in *Engineering* for details and arrangement of the engine. The engine is designed to lift ·500 imperial gallons (5,000 pounds) of water per minute 4,000 feet high; it being intended to work at five double strokes per minute, and to work ten pumps of 400 feet lift each, nine of the pumps having plungers, and the tenth being a bucket-lift. The dimensions given are: the two cylinders, respectively, 56½ and 113 inches in diameter, and a length sufficient for 10 feet stroke.

	Ft.	In.
Diameter of piston rods,	0	10
Depth of pistons,	1	10
Diameter of steam valve, high pressure,	0	8
" " " intermediate,	1	3
" " " exhaust,	1	6½
" quadrant centre pins,	1	10
Length " " "	3	3
Diameter of main pins,	1	0

The valves are of the Hornblower (lantern) type, and the *time* of lifting, controlled by permitting a lost motion in a link end for each valve rod. Attention is called to the small size of the steam valves, as compared with those demanded for engines other than pumping engines. Their adequacy, however, can be confidently affirmed; but even these dimensions would have been reduced by the use of the

poppet in place of the lantern valve: 6 inch, 11 inch, 13½ inch diameters, respectively, would have sufficed, and the same areas of steam passages have been retained. The side rod and lifter, with wiper shaft arrangement, so common with us, would have been more manageable than the lost motion link.

Lectures on the Weather and its Laws.—Prof. Wm. Blasius, who is very favorably known in the scientific world as the author of a Book on Storms, proposes to deliver a course of four lectures on the above subject. Prof. Blasius has made the subject a study of a lifetime and will unquestionably present in form for popular appreciation the general and very abstruse subject of meteorology. It will be gratifying if this effort to exhibit the relations of the observed phenomena of nature, so constantly watched and so much commented upon, as they have been found to exist, shall meet with success. These lectures will be under the auspices of the Philadelphia Board of Trade, and will be given at their Rooms, in the Mercantile Library building, Tenth Street, in January and February, 1877. The days on which they will be given will be hereafter designated. Tickets to the course will be $2.00 each, and those who shall desire to obtain them can do so, by addressing Messrs. Porter & Coates, 822 Chestnut Street, and Prof. Wm. Blasius, P. O. Box 2476, Philadelphia.

Alkalies in the United States.—In another part of this JOURNAL will be found a history of the Alkali manufacture in the district of Glasgow, Scotland, and it may be well to call attention to the consumption in the United States, as indicated by the report of the Chief of Bureau of statistics on commerce and navigation of the United States, in 1873, as follows: In the fiscal year ending June 30th, 1872, there were imported from Europe:

180,028,330	lbs of	Soda,	$3,465,644
28,351,423	"	Caustic Soda,	991,372
1,271,047	"	other salts of Soda,	17,930
15,358,525	"	Bi-carbonate of Soda,	405,253
36,439,597	"	Chloride of Lime,	950,668
261,448,922	lbs. of	Soda product,	$5,830,867

As all these products are bulky, and derived from the cheapest of raw materials, coal, salt, and limestone; the development of American chemical industry in this direction would appear to be one of the most obvious growths to be immediately anticipated.

SYSTEM OF AWARDS AT THE UNITED STATES INTERNATIONAL EXHIBITION OF 1876.

By Coleman Sellers.

An editorial in the December number of the Journal of the Franklin Institute, on the closing of the great exhibition, suggests a few words on what has been termed the American system of awards. The editor says, referring to former remarks of his own on the same subject. "The opinion was expressed that the examination of the judges would bring out the most striking novelties in mechanism, but this expectation has been frustrated by the action which has *awarded prizes to all.* And it is to be regretted, that no means have been otherwise provided for giving publicity or award for special merit." The italics are mine. It is too soon for an advocate of the system in theory, to speak knowingly in regard to the actual advantages of it in practice, but it is not too soon to correct a mistake which the editor, in common with many others, has been led into by the seeming lavishness with which awards have been granted, and in many cases advertised as the "highest." At least twenty-five thousand exhibitors know by this time, or will soon know that their exhibits have not been deemed worthy of any award; doubtless many of them can take just exception to the statement, that awards have been granted to all. The Hon. John Lynch, Chairman of the Committee on Revision, in answer to a recent letter from me, says: "The best information I can find, places the number of exhibitors at 40,000. This is based on the entries on the catalogue; the actual number will overrun this, as a large number of exhibitors are not found in the catalogue.

"The number of Judges' reports, recommending awards, is 13,688;[1] this number includes not only the reports recommending full awards, diploma and medal, but also reports simply recommending diplomas as recognition of merit, but, in the estimation of the judges not entitled to a full award. There are probably 1000 such. The number is also to be reduced several hundreds by duplicates, where judges of the different groups, by mistake reported on the same exhibit. These mistakes arose from the difficulty in determining to what group some exhibits really belonged."

[1] Live-stock awards are included in this number.

From these figures it is safe to infer that the real number of awards made will not reach over 30 per cent. of the whole number of exhibitors. There is yet to be made an analysis of the proportion of awards to exhibitors in each group. The information to enable this to be done is not yet accessible. Who could walk through those vast buildings and note the merits of the selected objects exhibited, and not think one-third of all worthy of some commendation? At London, Paris, and Vienna, medals of various values, either made of more or less precious metal, or engraved with legends which marked their grade of indicative merit, were given to the exhibitors upon the recommendation of international judges. The recipients of these tokens of honor knew only that their wares had been adjudged superior or inferior, by the nature of the award. The value of the higher awards lay in their rarity only. The value of the lower grades has been held by many exhibitors as rather doubtful. The student of the world's progress in the arts and sciences, pays little heed to these metal tokens, but seeks for information in the reports of the experts, sent out by various countries, and in the periodical literature of the time.

It is probable that the United States Centennial Commissioners had in view a possible means of crystallizing the thoughts and opinions of the judges, and making their reasons for each award form part of the premium. Added to this was another seeming advantage: "The awards shall be based upon written reports, attested by the *signatures of their authors.*" Looking over the list of the names of the judges, one cannot but think that some at least must have left the impress of their own mature minds on the judgments bearing their names as the authors. Such I have surely seen, and I cannot but hope these will at least point out for the guidance of future judges, how well such work can be done. The theoretical American award is one "based on inherent and comparative merit," the elements of merit being held "to include consideration relating to originality, invention, discovery, utility, quality, skill, workmanship, fitness for the purposes intended, adaptation to public wants, economy and cost."

About 200 international judges, arranged in groups so as to have each group as far as possible represented by native and foreign judges, have examined the products or wares of over 40,000 ex-

hibitors. They have deemed, we may safely say, 13,000 worthy of award. They have, doubtless, been compelled to use the same language in commenting on many similar worthy objects, but in so doing they simply say that these exhibits are of equal value. To appreciate the difficulties experienced in the first trial of this new system, one must place one's self in the position of a member of that international jury in this new work. The art catalogue alone numbers at least 3,600 exhibitors; may be, awards have been issued to 700. Let any one, by way of experiment, try to arrange words of the English language so as to make each one of the 700 reports differ from the other ones in order of merit. If all the work of the group judges is published, it will be seen that some have made really valuable contributions to our knowledge of the great exhibition. This will be most evident in those cases where reports, apart from the recommendation for award, have been made on every exhibit; that is, where all exhibits have been commented on, and those above a certain standard recommended for award.[1] I think it will be found that the American system of awards will prove to have resulted in a system of awards for intrinsic or actual merit rather than comparative merit. This may be just what the editor of the JOURNAL objects to; but it is probable that it really meets the case better and will satisfy more people than any expression of opinion by any set of men as to relative merit. Americans are very apt to make up their own minds as to relative merit; in some cases large numbers of independent observers may agree, but in most cases they do not. If some judicial body should declare some one sewing machine to be the *best* in the whole exhibition, such endorsement would not influence any of the many thousand users of other sewing machines. On the other hand, if men acting as experts in any particular department, and who are, as far as possible, free from personal bias, give an opinion on actual merit, such opinion usually is listened to and appreciated. So that, after all, there is reason to hope that much positively useful knowledge may yet be gathered for the working of judges on award; and it will be well for those thirsting for knowledge in this direction, "to possess their souls in patience" until the awards have all been published, which is not likely to be done for some weeks yet.

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[1] The report of Group II, on ceramics, will, if published entirely, make a large volume, and is full of valuable information.

Civil and Mechanical Engineering.

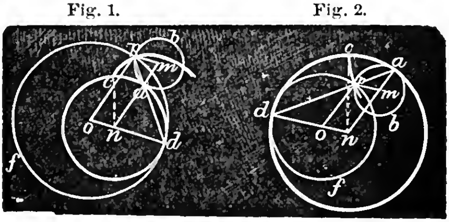
TEETH OF INTERNAL GEARS.

By A. K. Mansfield, M.E.

The chapters on the forms of gear teeth, which are found in the various text books on mechanism, invariably treat of the forms for external gears first, and then declare that the same reasoning and methods apply to the formation of teeth for internal gears. This assertion, however, is only true within certain limits. We therefore take this occasion to show that the theory of the formation of the teeth of internal gears depends on certain facts not entering into the theory of external gears, and therefore that the theory of the former requires a separate and distinct discussion. This theory depends in a great measure on the following proposition, before stating which it will be necessary to define, that by a negative circle is here meant one, the inside of whose circumference is employed; or the inside bounding circle of a ring.

Proposition.—Of three circles, the largest of which is negative, and whose diameter is numerically equal to the sum of the diameter of the other two, if either be employed as base, the other will describe the same epicycloid.

Fig. 1. Fig. 2.



Demonstration.—Let the epicycloid described by rolling one of the smaller circles on the other, be drawn (Fig. 1); also the internal epicycloid, or hypocycloid, made by rolling the same describing circle within the negative circle (Fig. 2).

Through any point p of the curve (either figure) draw the describing circle $a\,p\,b$ resting on the base; and through the same point draw the third circle, also resting on the base, but having its centre on the same side of the line of centres $m\,n$ of the first two circles, as the point p of the curve.

Since the curve was described by the circle $a\,p\,b$, therefore the arc $c\,a$ of the base, is equal to the arc $a\,p$ of the describing circle. Con-

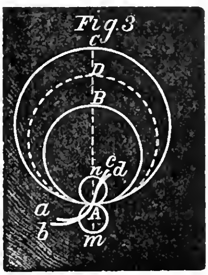
versely, if the arc $c\,d$ of the base, is equal to the arc $p\,d$ of the circle $p\,d\,f$, then the point p is also a point of the epicycloid, beginning at c, of the circle $p\,d\,f$.

Connect the points of contact a and d with the point p, and with the centre n of the base circle; also draw lines from p to the centres m and o of the describing circles.

Since $d\,n$ is a radius of the base circle, it is perpendicular to the point of contact d, and therefore passes through the centre o, of the circle $p\,d\,f$; and in the same way the line $a\,n$ passes through the centre m. Also since $n\,o$ is the difference between the radii of the base and one describing circle, it is, from construction, equal to the radius $m\,p$ of the other describing circle; and similarly $p\,o$ is equal to $m\,n$. $m\,n\,o\,p$ is therefore a parallelogram, and the angle $a\,m\,p = a\,n\,d = d\,o\,p$.

This angle subtends arcs of the three circles proportional to their radii, and since the sum of the radii of the two smaller circles is equal to the radius of the largest, the sum of the arcs of those two circles is equal to the arc of the largest. But the arc $a\,p =$ the arc $a\,c$, therefore $c\,d = p\,d$, and the point p is a point of the epicycloid, starting from c, described by the circle $p\,d\,f$; and this being any point that may be chosen, the same is true of all points of the curve.

Application.—Let $A\,B$ and $A\,C$ (Fig. 3) be the pitch circles of a pinion and an internal gear respectively, and let $A\,D$ be a describing circle, which rolled on the outside of $A\,B$, describes the curve $A\,a$, for the point of the pinion tooth, and rolled inside of $A\,C$, describes $A\,d$ for the point of the wheel tooth. According to the theory of Camus, which shows that epicycloids described by the same circle, work correctly together, the curves $A\,a$ and $A\,d$, or the *points* of the teeth of the pinion and wheel, will work correctly together, when described as above. But, according to our proposition, the curve $A\,a$ may also be described by rolling the circle $A\,m$, of a diameter equal to the distance $B\,D$, on the outside of $A\,B$; therefore from the theory of Camus, if the same circle $A\,m$ be rolled on the outside of $A\,C$, it will describe a curve $A\,b$ which will work correctly with $A\,a$, and may therefore be used to form the flanks of the teeth of the wheel. In the same way the circle $A\,n$, of a diameter equal to $D\,C$, if rolled inside the circle $A\,B$, will describe the curve $A\,c$, for the flanks of the pinion teeth. Thus the points of the teeth are formed to work cor-

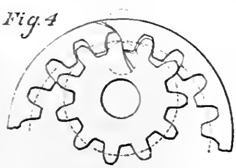


rectly together, as well as the flanks of the teeth of each gear to work correctly with the points of the other.

The circle $A\ D$ may have any diameter greater than $A\ B$, and less than $A\ C$; therefore to form the points to work together, we are only limited to making the sum of the diameters of $A\ n$ and $A\ m$, equal to the distance $B\ C$. If the sum of these diameters were less than $B\ C$ the points would not work together, and the action would be the same as in external gears; but if the sum were greater than $B\ C$ the curves for the points would cross each other, on one side of the line of centres, and the teeth would therefore *interfere*, making their correct action impossible. This leads to the following important rule: *The sum of the diameters of the describing circles for the epicycloidal teeth of internal gears, cannot be greater than the difference between the diameters of the wheel and pinion.*

When the pinion is small, relative to the wheel, it will often be convenient to make the sum of the diameters of $A\ m$ and $A\ n$ less than the maximum; but when the diameter of the pinion is equal to, or greater than, the radius of the wheel, a common describing circle of diameter equal to one-half of the difference between the diameters of the gears, may be the best to employ. The latter case is illustrated by Fig. 4. A principal reason for preferring describing circles of maximum size is, that when the points of the teeth act together, contact takes place through a much longer distance, which enables the teeth to be made shorter and therefore stronger. The path of contact of the points, is the circle $A\ D$ (Fig. 3), and of the points with the roots, the circles $A\ m$ and $A\ n$.

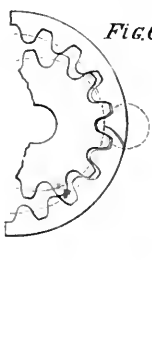
Fig. 4



If the diameter of one of the describing circles be equal to $B\ C$, the other becomes zero. In this case, one of the curves $A\ a$, $A\ d$ becomes a point in the circumference of its base circle, and the other curve works correctly with this point, as well as with its own corresponding flank curve $A\ b$ or $A\ c$. Fig. 5 illustrates the case in which the circle $A\ m$ becomes zero, and Fig. 6 that, in which $A\ n$ is zero. In each of these cases we have drawn a circle about the point mentioned, which made it necessary to

Fig. 5

Fig. 6

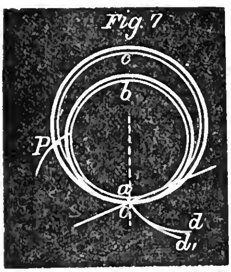


form the other acting faces of the teeth, of curves parallel to the epicycloids, at a distance from them, equal to the radius of the circle or point.

In the case of Fig. 5, if the diameter of the pinion be two-thirds that of the wheel, the flank of the pinion tooth becomes a straight line, parallel to the radius through the centre of the tooth.

By completing the circles which form the points of the teeth, and omitting the flank curves, we have the so-called pin wheels or trunnions, of which we distinguish three cases, viz.: Those in which the diameter of the pinion is (1) less than, (2) equal to, and (3) greater than the radius of the wheel. In case 1, the teeth should be given to the driver, and the pins to the follower, as in external gearing.[i] In case 2, the pinion should always receive the pins, since in that case contact will be equal on each side of the line of centres, whether the pinion be driver or follower. In case 3, it is immaterial whether the pinion or the wheel receives the pins, since in either case contact takes place before the line of centres when the wheel drives, and after when it follows; therefore, if the wheel drives, the objectionable contact, entirely before the line of centres, cannot be avoided.

Involute Teeth.[ii]—In applying involute teeth to internal gears it will be found, as before, that under certain circumstances the teeth interfere. For example, in Fig. 7, in which $a\ b$ and $a\ c$ are the base circles, and the curves $c\ d$, $c\ d$, the involutes of those circles, when the pitch circles are rolled about until the involutes arrive at the new position represented in the figure, they cross each other, at the point p. To avoid the consequent interference of the teeth, either smaller base circles must be employed, or the points of the teeth made short enough, so that the circles limiting those points cross each other either at, or before, the point p.



Internal gears work with much less friction than external, and occupy less space; besides which, the outer ring of the wheel forms a good shield to prevent accidents. For these reasons it seems advisable to use them in preference to external gears, when other considerations do not prevent.

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[i] See Willis's "Mechanism," § 132.

[ii] See the same, § 165

CERTAIN POINTS IN THE DEVELOPMENT AND PRACTICE OF MODERN AMERICAN LOCOMOTIVE ENGINEERING.

By Francis E. Galloupe, S.B.

Continued from Vol. cii, page 390.

The formula by which to calculate the strength of the cylindrical shell of a steam boiler, though very simple, is quite important, and may be thus deduced:—[1]

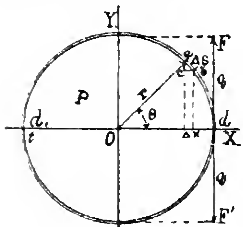

Fig. 1.

Let the figure represent a section or ring of the boiler whose internal radius is r inches; thickness t, in fractions of an inch; and its length, perpendicular to the plane of the paper, one inch or unity. Let this thin hollow cylinder be under an internal pressure, the intensity of which is p pounds per square inch, and let f be the ultimate tenacity of the material. This stress, p, is everywhere normal to the circumference, and the lines which represent its direction, of which there would be an infinite number, all radiate from the centre O.

The resistance of the material to this stress acts everywhere in a direction perpendicular to the direction of the stress p, or tangential to the circumference.

Consider the stress resisted by the cross-sections at d and d^1. The stresses along the horizontal axis X, in both directions from O, do not tend to burst it at these cross-sections. At d and d^1, the horizontal stresses tend to push out the lower half just as much as the upper, and there is no tendency to slide one cross-section by the other. Only the vertical stresses upon one-half the shell, in the direction $O\,Y$, tend to separate the cross-sections at d and d^1, and they are resisted by equal and opposite forces normal to these horizontal sections and represented by q, or $d\,F$ and $d\,F^1$.

Now, for any intermediate direction, let the stress p be represented in magnitude and direction by the line r, which makes any angle θ, with $O\,X$. Only its vertical component, $p \sin \theta$, acts, and the total

[1] There are a number of ways of proving this; one method is given by Rankine, another by Forney, and a different one still by Weisbach.

stress is the sum of all these components, acting upon one-half the circumference, from d to d^1, on the upper segment, or

$$P = \Sigma \cdot p \sin \theta.$$

Each of these stresses acts on a unit's length of cylinder and on a short arc in the circumference of a length $\triangle s$. Let fall from a and b, the extremities of this arc, perpendiculars on $O X$, and draw $b c$ parallel to $O X$. $a b$ is, for so short an arc, practically perpendicular to $O a$; hence the angle at a equals θ. Now $\sin \theta = \frac{b c}{a b} = \frac{\triangle x}{\triangle s}$.

Therefore, $P = \Sigma \cdot p \frac{\triangle x}{\triangle s}$, and integrating x, between the limits d and d^1, the arc drops out, or

$$\int_{-r}^{r} p \frac{d x}{d s} d s = p x \int_{-r}^{r} = p r - (-p r) = 2 p r.$$

The thickness of metal at d and d^1, to resist this total stress being t, its area is $t \times 1$, and the strength in lbs. per square inch, being represented by f, as above, the total resistance of the material $= 2 f t$. Therefore, if we put these results equal to each other we have, $2 p r = 2 f t$, or

$$p r = f t, \text{ and } p = \frac{f t}{r}, \; t = \frac{p r}{f}, \; r = \frac{f t}{p},$$

which express the relation between these four elements, by which we can obtain the value of either one when the other three are known.

To find the strength of the sections in resisting the pressure upon the ends, as upon the tube plates, we have the total pressure, $P = p \times \text{area} = p \cdot \pi r^2$. The resistance against rupture is that of the whole circular cross-section, or

$$\pi (r + t)^2 - \pi r^2 = 2 \pi r t + \pi t^2 = 2 \pi r t \left(1 + \frac{t}{2 r}\right).$$

Now, as the ratio $\frac{t}{2 r}$, of the thickness to the diameter is a very small fraction, in this case being $\frac{\frac{3}{8}}{48} = \frac{1}{128}$, it may be neglected, and the resisting area assumed to be represented by a rectangle of the length $2 \pi r$, and width t. Multiplying by f, we have the total resistance $2 \pi r f t$, and $2 \pi r^2 p = 2 \pi r f t$, or

$$p r = 2 f t, \; p = \frac{2 f t}{r}, \; t = \frac{p r}{2 f}, \; r = \frac{2 f t}{p},$$

or the pressure upon the ends may be twice as great as in the former case.

In these formulæ the assumption is made that the stress is uniformly distributed over the cross-section, which is only approximately true for thin shells. In the sphere we have the latter case for every diametral section, and hence the sphere is the strongest of all known forms for steam boilers. Internal pressure tends only to preserve its shape; if from any cause a spherical boiler is out of shape, the pressure would tend to reduce its distortion and restore it to the true spherical form. The sphere also contains the greatest volume within a given amount of surface or material. As far then as strength alone is concerned, we see why boilers should have the spherical form.

To ascertain the reduction of strength due to the riveted joints, there are a number of easily deduced formulæ which give approximately the best relations in practice between the thickness of the plate, and the diameter and pitch of the rivet. The strength of the plates along the line of rivet holes, according to deductions made from Sir Wm. Fairbairn's experiments, by Wilson in his "Treatise on Steam Boilers," after taking into consideration the loss of strength due to the treatment the iron has received, the diminished section of plate through the line of rivets, and the excess of strength in long over short lines, is regarded as 70 per cent. for double riveting, and 56 per cent. for single, of the strength of the entire plate.

The rivets in this boiler are $\frac{11}{16}$ inch in diameter; heads, 1 inch in diameter $\times$ $\frac{3}{4}$ inch in height; set, the first row $1\frac{1}{4}$ inches from the edge of the plate; the second, $2\frac{1}{4}$ inches; and the pitch, 2 inches or $1\frac{15}{16}$ inches.

The plates in a steam boiler are under these conditions: First, there is an indirect strain upon the rivets and plate, on account of the overlapping joint, for the internal pressure causes a tension, the line of action of which passes through the centre of the united plates, and thus tends to bend the rivets out of their original position at right angles to the plates. Next, the plates lose strength on account of an irregular distribution of the stress coming upon them, due to the punching of the plate for the rivets. And finally there is the loss of strength due to the amount of material cut away for the rivet holes, and the action of the rivet in producing strains in the plate.

The weakness of the joint may exhibit itself in a number of ways, —by the plate in front of the rivet crushing, by the rivets shearing off, the plate tearing between the rivet holes, splitting from the rivet holes to the edge of the plate, or by the plate being forced out by a wedge-like action of the rivet; all of which have to be considered in determining the greatest strength attainable with our present system of riveted boilers.

If we call, in the present case, the diameter of the rivet $d = \frac{11}{16} = \cdot6875$ inch; the thickness of the plate, $t = \frac{3}{8} = \cdot375$ inch; and the pitch, $p = 2$ inches; and take the resistance of the plate to crushing at 40 tons per square inch, the first of these, the resistance of the plate to crushing by each rivet, would be:

$$d \times t \times 40^{1} = \cdot6875 \times \cdot375 \times 80{,}000 = 20{,}624 \text{ pounds.}$$

Second, the ultimate shearing strength of the rivet, calling the resistance to this strain, 21 tons, is found by multiplying the area sheared by the strength per square inch, or

$$\tfrac{1}{4} \pi d^2 \times 21 = \cdot7854 \times \cdot4726 \times 42{,}000 = 15{,}586 \text{ pounds.}$$

The condition for the greatest economy in material is that when these two values are the same, or the strength of the rivet and plate are equal, any excess of strength one above the other being of no value. This condition is represented by putting these two terms equal to each other, or

$$d \times t \times 40 = \cdot7854 \times d^2 \times 21,$$

whence $d = 2\cdot4\ t$. Judged by these two requirements alone, the diameter of the rivet should be ·9 inch instead of ·68; but it agrees with the common rule of making the diameter double the thickness of the plate.

Third, the strength of the plate left between the rivet holes, *for a single row of rivets*, may be found by the equation, $R = t\ (p - d)\ 21$, or $\cdot375\ (2\cdot00 - \cdot75)\ 42{,}000 = 19{,}688$ pounds. In this the diameter of the rivet hole is taken at $\frac{3}{4}$ inch, or $\frac{1}{16}$ inch larger than that of the rivet, as this has been found to be the average size in practice. Now for equality between the strength of the rivets and of the plate left between the holes, we form the equation,

$\frac{1}{4}\ d^2 \times 21 = t\ (p - d)\ 21$; from which the proper pitch to be employed is found to be $p = \dfrac{a}{t} + d$, a being the area of the rivet.

[1] These formulæ are Wilson's, and his value of the ultimate resistance of the material to the different stresses are taken as being reliable and probably below that of the material in this boiler.

For a double riveted lap joint, Mr. Wilson states that we have the sectional area of two rivets to shear instead of one, and employs the formula $2\,a = t\,(p - d)$; whence,

$$p = \frac{2\,a}{t} + d = \frac{\cdot 7422}{\cdot 375} + \cdot 687 = 2\cdot 66,$$

or about $2\frac{5}{8}$ inches instead of 2 inches, which it has in this case.

From the strength of the plate to resist splitting from the rivet to the edge, we ascertain the proper distance that the first row of rivets should be placed from the edge of the plate. This is done by considering the plate as a girder fixed at both ends and uniformly loaded, by which we find, roughly, that the depth $h = \cdot 81\ d$, which indicates that in this case the depth of $1\frac{1}{4}$ inches comes far within this requirement, upon the safe side.

The consideration of the last effect, or the wedge-like action of the rivet, is unnecessary, as the resistance in this case exceeds that in all the other respects.

In locating the second row for the double riveted seams, a circular arc is described from the centres of two successive rivets in the first row, and with a radius equal to one-half the pitch. The intermediate rivet is located so that its circumference is tangent to each of these arcs. Now the shortest distance between two holes is that between two rivets in a diagonal row, and is equal to $\frac{1}{2}\,p - \frac{1}{2}\,d$, or $\frac{1}{2}\,(p - d)$. The resistance of this portion of plate is, therefore,

$$\tfrac{1}{2}\,(p - d)\,t \times 21 = \tfrac{1}{2}\,(2 - \tfrac{3}{4})\,\tfrac{3}{8} \times 42{,}000 = 9{,}840 \text{ pounds.}$$

The section of plate, and consequently its strength, between three successive rivets, irrespective of the rows they are in, is therefore equal to that between two successive rivets in the same row; and the ratio that the strength of this portion of plate bears to the whole plate is as the length, $(2 - \frac{3}{4})$, is to the pitch, 2 inches; or $62\frac{1}{2}$ per cent.

The boiler as a whole derives additional strength from the length of seam, the breaking of joints, and especially, by the double thickness at the overlapping edges around the circumference. The amount of this is considered to overbalance the loss due to punching, and the unequal distribution of stresses, sufficiently to make it safe to take the strength of the double riveted seams as at 70 per cent. of the strength of the boiler plate. Where the single riveting exists, we have seen that the stress is but one-half that upon the double riveted, while the strength of the seam is 56 per cent.

of that of the entire plate, or much greater than half of 70 per cent., and these seams may hence be left out of consideration.

We may now determine the actual boiler strength. Applying the formula that has been deduced, $f = 52{,}102$, $t = \frac{3}{8}$ inch, $r = 24$ inches. Hence the ultimate, or bursting pressure,

$$p = \frac{f \times t}{r} = \frac{52{,}102 \times \frac{3}{8}}{24} = 814{\cdot}1 \text{ lbs. per square inch.}$$

seventy per cent. of $814{\cdot}1 = 569{\cdot}87$ lbs. Now, to determine with what factor of safety this locomotive is running, we have the usual steam pressure, varying from one hundred and forty, to one hundred and forty-four or five pounds, and it being not improbable that from a slight cause it would reach one hundred and fifty, $\frac{569{\cdot}87}{150} = 3{\cdot}8$, and at 140 lbs. pressure the factor of safety is but 4. If it was not for constant attendance, this might be regarded as rather hazardous, and 6, as given by Rankine and Wilson, would be the better figure. This result indicates the great difference between the factors of safety of different parts, the mechanism in some parts having as great a factor as 30, while the positive, live force of steam has but 3 or 4. From the wearing or corroding of the plates they become thinner, a usual rule in regard to which being to deduct one-fifth for deterioration after several years; and this is allowed for, in the locomotive, by reducing the working pressure, perhaps 20 lbs., and running at 120 lbs., making of it what is known as a second class engine.

It is unnecessary to calculate the strength of other parts, such as the tube sheets, which are thicker and heavily stayed, and the fire-box flat sides; for these are determined by other considerations, such as stiffness, and resistance to bulging. The unvarying rule is that the fire-box stays shall not be more than four inches apart, and they are usually twice the thickness of the plates in diameter.

In the flues the tendency of pressure is the opposite of that on the shell. While, in the shell, internal pressure tends to make it a perfect cylinder, in the tubes, a slight distortion is further increased by the unbalanced external pressure; but from their small diameter the strain resulting from the compressive force, is not, in general, equal to that exerted by pressure on the shell.

The collective pressure inside a locomotive boiler is immense. To obtain some idea of what it would be, the calculation was made for the

shell alone. Its volume, exclusive of the tubes, is very nearly 100 cubic feet. The number of square feet of surface in the shell is 138·23; on each tube plate, after deducting the area of the tubes, 9·05; and on the tubes 927·3. On every square inch of this there is a pressure of 140 lbs., or 20,160 lbs. upon the square foot, so that upon the shell alone it amounts to 2,786,717 lbs.; on the tubes alone, 9,344 tons; and the total upon the boiler, 10,740 *tons*.

But there are other forces much more violent than this which the locomotive boiler has to daily withstand. It has been stated that the boiler is the back bone of the locomotive engine. Upon it are placed many attachments; it is cut up by large holes and most of the sheets punched for stay bolts, braces and outside attachments, whose weight alone tends to distort it. Then there is the force of expansion which is very unequal in different parts. On raising steam in this boiler it lengthens from $\frac{3}{16}$ to $\frac{1}{4}$ inch. Formerly no allowance was made for this in bolting it to the frame, and the immense stress thus produced caused it to rise in the centre, but which was partially counteracted, however, by the weight of the water, which in this boiler with two gauges full is 3,125 lbs., or over a ton and a half. As now constructed, the side-frames are supported at the fire-box end in straps which permit the boiler to slide along the frames during expansion and extend back into the cab. The frames are placed $\frac{1}{2}$ inch from the sides of the fire-box, and notwithstanding the fact that the expansion or bulging out of the plates must be greater inside the fire-box because of the high temperature, the external fire-box is found to expand $\frac{3}{32}$ inch towards the frames.

As a whole, the apparently rigid boiler is not so in reality. It is yielding in every direction, and the elasticity of iron is at once an advantage and a defect in the use of the material for locomotive construction.

The Furnace, in a locomotive, consists of the external fire-box, whose parts include the furnace door, the ash pan and ash pan dampers; and the internal fire-box, whose parts are the grate, the crown sheet, crown bars and furnace stays. It is strengthened on its large flat surfaces by stay bolts, which are sometimes made hollow, both to admit air to the gases above the fire and to give warning by leakage when they become useless from corrosion. These are screwed into each plate and riveted upon the ends. The crown sheet is strengthened by double, or pairs of, crown bars; each

bar of a pair is $\frac{3}{4}$ in. in width by 5 inches in depth, the double bars placed $4\frac{1}{2}$ inches apart. Each pair is joined together by welding at the ends, and is attached to the crown sheet by bolts passing between them. The crown bars are set off from the crown sheet by smooth, circular washers, $\frac{1}{2}$ inch thick, which allow the circulation of water around them, beneath the crown bars, over the surface of the plate.

II. *The Heating Surface* includes all the internal surfaces of the boiler exposed to the hot gases upon one side of the plate and in contact with the water upon the other. Its extent is limited, practically, only by the size of the boiler. The more that can be introduced in it, the greater the available heat, of the total produced by the combustion of the coal. The usual ratio to grate area is 50 square feet for each square foot of grate.

The dimensions of the fire-box of this engine, it will be seen by the specification, are 60 inches length, $35\frac{5}{8}$ inches width, and 66 inches in height, the metal in the sides and back, and in the crown sheet, being $\frac{5}{16}$ inch in thickness, and that in the tube sheet $\frac{7}{16}$ inch. The grate area is therefore $60 \times 35\frac{5}{8}$ inches $= 14{\cdot}84$ square feet, and by the above rule the total area of heating surface should be $14{\cdot}84 \times 50 = 742$ square feet.

The actual heating surface is as follows:—

Heating surface in tubes $= 2\,\pi\,r \times l \times n = 6{\cdot}2832 \times 1 \times 132 \times 161 = 927{\cdot}2956$ square feet.

Heating surface in fire-box. Back end, $2{\cdot}9687$ feet $\times$ 5·5 (height) — 1·3893 sq. ft. (area of door) = 14·9366 sq. ft. Front end, 16·3259 — 3·5098 (area of tubes, $\pi\,r^2\,n$) = 12·816 sq. ft. Sides, $5 \times 5{\cdot}5 \times 2 = 55$ sq. ft. Crown sheet, same as grate area, 14·8435 sq. ft.

The area of heating surface in the front tube plate is equal to the area of the cross-section of the shell, diminished by the area of the tubes, or $12{\cdot}5664 - 3{\cdot}5098 = 9{\cdot}05$ sq. ft., and neglecting this, since it is practically of no value as heating surface on account of the comparatively low temperature of the gases in the smoke-box, it being regarded as doing no more than to maintain the heat already in the water, the total heating surface may be expressed as follows:

Total heating surface in fire-box,	97·596 square feet.
" " " in tubes,	927·295 " "
Total heating surface in boiler,	1024·89 square feet.

(To be continued.)

TRIAL OF THE PUMPING ENGINES AT LAWRENCE, MASS.[i]

By Theron Skeel, C. E.

The report of the trials of these engines,[ii] is of great interest to the engineering profession, and to all interested in the problem of the water-supply of large cities, particularly as it may be compared with that of the pumping engines at Lynn, Mass.[iii]

The engines in the two cases were of nearly the same size, and delivered almost exactly the same volume of water to nearly the same height. They were designed by the same engineer (Mr. E. D. Leavitt, Jr.), and erected by the same contractors. The experiments were made by the same gentlemen, in the same manner, and the records are sufficiently full in each case to give an intelligent understanding of the results.

A criticism of the report of the Lynn engine was published in the *Engineering and Mining Journal*, in March, 1876. The object of this paper is to compare the results of this experiment with those deduced from the records of that at Lynn, and to see how far the one verifies the other.

The duty of the engine at Lynn, as computed by Mr. R. H. Buel and the writer, by crediting the engine with the actual volume of water delivered (the pressure against which it pumped, being that which it was supposed would have been indicated by a correct pressure-gauge located at the level of the water in the pump-well, and connected with the force-main beyond the pump + one pound, which was an allowance for the supposed resistance of the passages between the well and the pump), and charging it with the weight of the combustible portion of the coal actually consumed + one-fifth of that weight (being an allowance for the ashes and refuse usually found in commercial anthracite coal), was $87\frac{1}{2}$ millions for 100 lbs. of commercial anthracite.

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[i] From the *Engineering and Mining Journal*, November 25, 1876.

[ii] Journal of the Franklin Institute, vol. cii, p. 312.

[iii] Journal of the Franklin Institute, vol. xcvii, p. 29; vol. xcviii, p. 404; vol. xcix, p. 43.

The coal used in the experiments at Lawrence was "Cumberland," having 4 per cent. of ashes and refuse. A considerable number of experiments on anthracite and semi-bituminous coal, including "Cumberland," made by the United States Navy Department, and published in "Experimental Researches in Steam Engineering," by B. F. Isherwood, and elsewhere, have shown that the effect of the combustible portion of these coals when burned in the furnaces of steam boilers, similar to those at Lawrence, are *sensibly equal.* If there is any advantage, it is in favor of the semi-bituminous combustible, and the engine at Lawrence will certainly not lose anything by assuming the combustible to have been equal to that at Lynn.

In the report of the experiment at Lawrence, the Board of Experts have quoted paragraphs from their letter of instructions from the Water Commissioners, and have explained how the experiments were made, and how the calculation of what was termed the *duty* in those instructions was made.

The instructions appear to have been (so far as the points to be criticised in this paper are concerned) briefly as follows:

1st. To measure the water actually delivered by the pump.

2d. To ascertain the pressure in the rising main, near to the pump, by a correct pressure gauge.

3d. To weigh the Cumberland coal supplied to the furnaces of the boilers during an interval of forty-eight hours, said interval to commence at any time they might choose, the engines having been previously running uniformly, and the fires in good condition.

4th. To compute the "duty" by crediting the pumps with the weight of water actually delivered + 5 per cent., with the height equivalent to the pressure shown by the gauge + the statical height of the gauge above the surface of the water in the pump-well + one pound, and by charging the engine with the weight of coal actually fed to the furnaces.

It is not necessary to point out that the quantity called the "duty" when computed in this way, does not resemble the duty as ordinarily understood in any way whatever. The duty as ordinarily understood is the useful work done by one hundred pounds of coal, the useful work being the weight of water delivered by the pumps, lifted to a height equivalent to the pressure in the pipe through which the pump delivers. The experts in this case were required to measure the volume of water delivered and the pressure resisting it, and then to

declare that the pump had delivered 5 per cent. more water against one pound more pressure than their experiments showed.

One will not deny the propriety of an inspector cutting an inch off from the end of his yardstick before he measures a roll of cloth, provided the buyer and the vender direct him to do so, but care should be taken that the transaction is not placed on public record as an equal number of *standard yards.*

The allowance of 5 per cent. of the volume of water was ostensibly made to "allow for the loss of action" in the pump. In one experiment the pump delivered about 95¼ per cent. of the piston displacement, and the allowance of 5 per cent. increased this to 100¼ per cent. of the piston displacement, so that there is in this case the anomaly of the pump being credited with more water than it could hold.

The allowance of "one pound" was also made to allow for the "friction of the pipe and bends" between the well and the pump. In this case there were no such pipe and bends. The pump had an open bottom and was set directly in the well, the water in the well surrounding the pump barrel and the surface being considerably above the suction valves in the pump. The gauge was placed in the air-chamber of the pump, and thus measured the pressure of the water before it had been reduced by any friction except those of the pump-valves and passages. There would appear to be no more reason for adding one pound than for adding one hundred.

In computing the "duty" according to the instructions already quoted, the board would appear to have made one slight error. The specific gravity of the water was determined to be, by experiment, 1·005, distilled water at 60° being 1·000. From this the board computed correctly the weight of a gallon to be 8·38 pounds, but in computing the hydrostatic head, equivalent to the pressure of 75·85 (being the pressure shown by gauge + pressure equivalent to height of gauge above surface of water + one pound), they neglected to consider the actual specific gravity of the water, but assumed the greater height corresponding to a liquid having a specific gravity of 1·000. The error from this cause is nearly one-half of one per cent.

The engines were a pair of compound beam engines, coupled at right angles to a crank shaft and having one fly-wheel for both engines. Each engine consisted of a high pressure and a low pressure

cylinder at opposite ends of a working beam, and one "bucket and plunger" pump. Each engine had its own air pump, feed pump, and steam pipe, and the pumps delivered through separate water mains which united seventy-five feet from the engine-house. It is presumed there was a stop valve in each of these branch mains. The pumps had open bottoms, and stood directly in the pump well, the water surrounding the pump barrel and rising up considerably above the suction valves. The steam cylinders were steam jacketed on the sides and lower heads, the water of condensation from the jackets returning (it is presumed) directly to the boilers after being measured in the feed water tanks. There were two boilers of the locomotive type, the products of combustion passing first through the tubes and then returning through a brick flue under, and in contact with, the lower part of the shell of the boiler. The pump valves were the "Cornish Double Beat" type.

The Board of Experts made two sets of experiments, the one for economy being two runs, one of 22 hours, the other of 35 hours, with an interval of three hours between. The engine was stopped during one and a half hours of this time to repair "the pipe which had been inserted into the pump chambers for the taking of indicator cards" which had blown out. During these two runs the engines were uncoupled (it is presumed in such manner that all parts of the engine not in use, except the crank shaft and crank, were at rest) and one engine only run. A portion of the grate surface in each boiler was bricked off and both boilers were used. The water delivered by the pump was measured by a weir, and the pressure in the air chamber of the pump, together with the elevation of the gauge above the surface of the water in the well, which varied a little during experiment, noted every hour. The feed water (inclusive of that condensed in jackets) was measured in a tank, the coal fed to furnaces weighed, and indicator cards taken from the steam cylinders and various pressures and temperatures. The ashes withdrawn from the furnaces were also weighed.

The third experiment, being for capacity, was made with both engines and boilers (the bricks from the grates having been removed). That experiment lasted 35 hours, and was made in the same way, except that no indicator cards were taken from the steam cylinders.

The *nominal duty*, as computed by the Board, was:

Economy test (average), . .	96,186,979
Capacity test, ...	not computed.

If this result is reduced one-half per cent. to allow for error in computing height equivalent to pressure shown by gauge, the resulting figures (being a quantity computed as instructed and called in contract *the duty*) will be $95\frac{7}{10}$ millions.

There was an air cock on the suction pipe intended to admit air to the pump, but it is inferred from the language of the report that *this cock was not opened during these experiments.*

Comments upon the details of the report, in their natural order, will be as follows:

COAL.—The coal was "Cumberland," said by the Board to have been of good quality. Two kinds were used during the economy trial, the second kind being substituted in hopes of an improvement in the evaporation, but without success. The proportion of ashes and cinders was $3\frac{8}{10}$ per cent. Ordinary commercial Cumberland coal yields from 10 to 12 per cent. of ashes and refuse when burned in furnaces similar to those at Lawrence, tended by ordinarily skilled firemen.

RATE OF COMBUSTION.—The combustible portion of the coal was consumed at the rate of $\frac{16}{100}$ of a pound per square foot of heating surface per hour in the economy trials, and $\frac{26}{100}$ in the capacity trials. The temperature of the gas leaving the boilers was in the first case below the temperature of the steam, and in the second case varies from 20° cooler to 70° hotter than the steam. The low temperature of the gas may be have been caused either by leakage of air into the flues or by radiation of heat; in either case the economy of the boiler in the first experiments would have been improved by an increase of the rate of combustion until the gas was as hot as the steam. One would expect that the evaporation would be better in the capacity trial than in the economy. The actual results were in pounds of water evaporated from 212° by one pound of combustible:

Economy trial, ...	10·1
Capacity trial, ...	10·3

The engine, therefore, did not have any advantage in using two boilers during the economy trial.

MEAN PRESSURES IN CYLINDERS.—The mean indicated pressure as given in the report in the high pressure cylinder during the economy trial was 53·74 pounds, and on the low pressure 10·22 pounds. All of this pressure, except that necessary to overcome the friction

of the engines and of the bucket and plunger of the pump, must be balanced by the pressure of the water in the pump cylinder. The experiments on the similar engine at Lynn indicated that 2 pounds per square inch on the low pressure piston was sufficient to overcome all friction of machine and to work the feed and air pumps. Making the same allowance here, the unbalanced pressure transferred to the pump bucket was 84·7 pounds per square inch of pump bucket, while the pressure shown by the gauge on the air chamber + the statical head from the gauge to the level of water in the well was 74·84, showing that the pump required nearly 10 pounds per square inch of bucket to overcome the resistance of the valves and passages in the pumps, or 13 per cent. of the useful work.

Friction of Water in Main.—A comparison of the hydraulic head as indicated by gauge and of the statical head shown by preliminary survey shows the friction of the whole length of main from the pump to the reservoir.

	Head in feet.		
	Hydraulic.	Static.	Difference.
Economy trial, ...	172·0	168·7	3·3
Capacity trial, ...	176·4	169·7	6·7

The mean velocity of the water through the pipe in feet per second was, during the trial for economy, $1\frac{57}{100}$, and during that for capacity, $2\frac{56}{100}$. The loss of head from friction would theoretically be proportional to the squares of these numbers, or as 25 to 65.

Calculation of Friction of Water in Main.—The friction of the water in the short branch mains, 75 feet long, may be disregarded as insensibly small. The friction of the water in the long main during the capacity experiment, when the pipe was receiving 4 discharges from the pump each revolution, or 65 per minute, and the velocity therefore sensibly constant and $2\frac{56}{100}$ feet per second, may be computed from the formula given in Rankin's *Civil Engineering*, page 678, edition 1867, and for both cases, will be found to be in feet of water:

Economy trial, ...	= 2·2
Capacity trial, ...	= 4·2

being about $\frac{1}{3}$ less than that found by experiment in each case. The difference being $2\frac{1}{2}$ feet in the capacity experiment, and $1\frac{1}{10}$ feet

in the economy, may have been absorbed in overcoming the friction of the bends and of two sets of gates in the main.

Resistance of Valves.—This was found to be from difference of steam pressure on steam pistons and water pressure shown by gauge in air chamber very nearly 10 pounds acting on the whole area of the bucket during one-half a revolution, from which it would appear that the force required to drive the water through the pumps, including the resistance of valves, was nearly 7 pounds per square inch, or 3 pounds for each valve. In the engine at Lynn, by the same builders, this force was only about 2 pounds, or less than one pound for each valve. The dimensions of the valves are not given with sufficient detail to compute the force required to lift them, but it may be inferred that the annular area tending to lift the valve was at Lawrence 23 sq. in., and at Lynn 60 sq. in. If the valves should weigh 100 pounds in each case the force required to lift them would be $4\frac{1}{4}$ pounds at Lawrence, and $1\frac{2}{3}$ pounds at Lynn. These figures serve to show that the additional resistance at Lawrence might be entirely due to the peculiar construction of valves.

The object in substituting "double beat valves" for disc valves was undoubtedly to obtain a greater opening for the passage of water, and thus allow it to pass through the pumps with less resistance. The construction of these valves entirely defeated that object, for the head required to open them (3 pounds) was sufficient to have forced all the water pumped through a single orifice 10 inches in diameter, being very much smaller than it would have been necessary to use with disc valves.

Note.—This condition of affairs appears to be not unusual in pumps using valves of this description. In the report of Citizens' Committee of Chicago, 1875, I find the pressure required to open valves (being the difference between the indicated pressure in the pumps and that shown by gauge outside) was 6 pounds for each set of valves. The valves in that case had almost identically the same dimensions as at Lawrence, namely, $15\frac{11}{16}$ inches diameter of outside of lower seat and $12\frac{3}{8}$ inches diameter of inside of upper seat. The effect of this large resistance was to reduce the useful work nearly 25 per cent.

Water Condensed in Jackets.—This was found to be by an experiment made afterward, when the steam in the boiler was from 70 to 75 pounds, at the rate of 339 pounds per hour. During the experiments on the engines the steam averaged 90 pounds. Probably

the steam condensed during the experiments was at the rate of 360 pounds per hour.

DUTY.—I estimate the duty per pound of combustible, calculated on the actual volume of water delivered, on the pressure indicated by the gauge + the statical height of the gauge above the surface of water in well during test for *economy :*

$$27{,}650 \times 74 \cdot 85 \times 144 \div 3 \cdot 14 = 94\tfrac{9}{10} \text{ millions,}$$

and during test for *capacity :*

$$45{,}200 \times 76 \cdot 73 \times 144 \div 5 \cdot 287 = 94\tfrac{1}{2} \text{ millions,}$$

the mean of both being $94\frac{7}{10}$ millions, from which it may be computed that with commercial anthracite coal having $\frac{1}{6}$ ashes and refuse, the duty would be $78\frac{1}{10}$ millions. This is the actual *commercial duty* of the engine as shown by these experiments.

COMPARISON OF ENGINE AT LAWRENCE WITH ENGINE AT LYNN.—A careful comparison of the performance of the engine at Lawrence with the engine at Lynn will show as follows :

	Lawrence.	Lynn.
Pounds of water evaporated from 212° by one of combustible, ...	10·1	12·2
Pounds of water per indicated horse power per hour, ...	14·4	16·8
Pounds of combustible per indicated horse power per hour, ...	1·64	1 60
DUTY.—Calculated on the actual volume and pressure of water and for 100 pounds commercial anthracite having $\frac{1}{6}$ ashes and refuse (millions), ...	$78\frac{1}{10}$	$87\frac{4}{10}$

It appears that the boilers at Lynn were a little more economical than those at Lawrence, but that this advantage was nearly overcome by the economy of the engine at Lawrence being greater than that at Lynn (probably on account of the higher steam pressure and greater expansion), leaving the cost of an indicated horse power in combustible nearly the same in each case. The engine at Lynn only lost 9 per cent. of the useful power in overcoming all resistances of the engine and pumps, while the engine at Lawrence lost 18 per cent., the proportion of the indicated power utilized being, at

Lynn, ...	92	per cent.
Lawrence, ...	84	"

The engines and pumps (except the valves) were almost identical in each case. The chief cause of difference, therefore, was probably in the valves in the pumps.

SACCHAROMETER OR POLARISCOPE OF M. LAURENT.

Translated for the JOURNAL OF THE FRANKLIN INSTITUTE,

By ROBERT BRIGGS, C. E.

From the French of M. l'Abbé Moigno [*Les Mondes*, 16 Novembre 1876].

This new saccharometer has been arranged from an altogether practical point of view, so as to make the manipulation of the instrument as simple as possible, and yet preserve all desirable precision; and this result has been attained by a novel construction of the burner and its "*cup*," which gives a much more intense light than proceeds from ordinary burners, burning satisfactorily under low pressure, and not demanding any more than the usual quantity of gas.

A sketch view of the apparatus is shown by Figure 1, which is a longitudinal section, in elevation, except that the arms *J K*, shown vertical in the figure, are horizontal in actual construction.

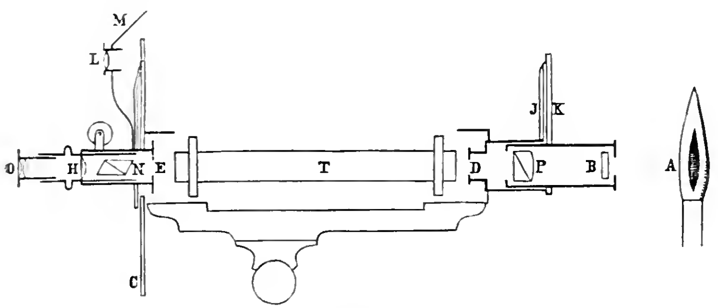

Figure 1.

A. Monochromatic *yellow* flame, placed at an invariable distance from the instrument (supported by a fixed standard shown in Fig. 6). *B*. Diaphragm containing a plate of bichromate of potash, for the purpose of absorbing the violet and blue rays contained in the flame, and permitting the useful yellow rays to pass intact. *P*. Double refracting prism, within which the second image is thrown aside and intercepted by the diaphragms. *D*. Diaphragm carrying a thin plate of quartz *parallel* to the axis, *the thickness of which is a half wave*, for the yellow rays. *E*. Diaphragm. *N*. Nicol analyzer. *H*. Object glass. *O*. Concave eyepiece, forming with *H* a Gallilean system of lenses. *T*. Tube containing the solution to be examined. *C*. Divided circle, having one or two sets of division; the one especial for sugar, and the other in half degrees of the circle, for substances of any power of rotation whatever. *L*. Eyepiece to read the divisions. *M*. Mirror which reflects the light from the burner *A* upon the divisions, and avoids the necessity of another light.

The system of polarization will be seen to present a novel optical arrangement. It is composed of two distinct parts: the double-refracting prism P, which can be rotated to a small extent by the arm K, and the diaphragm D with its half plate of quartz. Figure 2

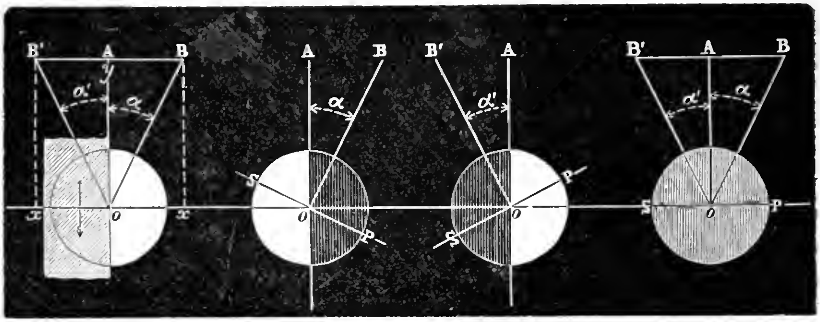

Fig. 2. Fig. 3. Fig. 4. Fig. 5.

represents the diaphragm D of the Figure 1 enlarged, as it will appear in the instrument. The left half is covered by the plate of quartz, the axis of which is parallel to the line of separation $O\,A$, and the right half, which is naked, allows the rays, which have been polarized by the polarizer P (Fig. 1), to pass without deviation. Suppose the plane of polarization to be parallel to $O\,A$ (Fig. 2). If it is permitted to remain unchanged, and if the analyzer N (Fig. 1) be turned, there will be a passage made progressively, from total extinction to maximum of light, and the two halves of the disc will, throughout these changes, one remain equal to the other in intensity, exactly as if the plate of quartz did not exist. The plate remaining unmoved, let it be supposed that the polarizer P is turned, so that the principal ray coming to $O\,B$ makes any angle whatever, α, with the axis $O\,A$. It follows then that the vibration accomplished within the plane represents by its trace $O\,B$. This vibration represented in its length by $O\,B$, may be decomposed into two others, the one $O\,y$, parallel to the axis $O\,A$ of the plate, and the other $O\,x$, perpendicular to this axis. This vibration passes to the right hand without deviation, but on the left hand it will be deviated by the plate. The ordinate $O\,y$, parallel to the axis of the quartz, does not change its sign, but the abscisse $O\,x$, which is perpendicular to it, does change its sign, and passes to $O\,x'$ or 180°; since the plate of quartz has the thickness of a half wave, it follows that on the left hand,

the resulting vibration will be to $O\,B'$, and makes with the axis $O\,A$, an angle α' symmetrical and equal to α. The purpose of this plate is then seen to be, to move to the left a part of a principal ray $O\,B$, which it places in regard to the line of separation $O\,A$, symmetrical to the proper place of the principal ray $O\,B$ on the right hand. If the polarizer is allowed to remain fixed in this position, and the analyzer be turned so as to bring the principal ray $S\,P$ perpendicular to $O\,B$, Fig. 3, there will be a total extinction on the right side, but a partial one on the left, appearing as shown in Fig. 3. Reciprocally, if the principal ray $S\,P$ of the analyzer be perpendicular to $O\,B$, Fig. 4, there will be a total extinction for the left side, but partial for the right, as indicated in Fig. 4. Finally, if the principal ray $S\,P$ of the analyzer be perpendicular to $O\,A$, Fig. 5, there will be a partial extinction on both sides and equality of shade, because $\alpha = \alpha'$, and thus will result the appearance, Fig. 5. If, however, the analyzer is permitted to remain fixed in this last position, and the polarizer now be turned, so that the principal ray shall make angles, varying from 0° to 45°, with $O\,A$, the two half discs remain always equal in intensity one with the other, of shade; but the two will change, progressively, their common intensity in passing from total extinction to the maximum of illumination. In other words, if the instrument be regulated to zero, that is, to equality of shade, and the polarizer be turned, no change in the equality of shade will occur, in consequence of being in the zero position, but solely a change of intensity, common to the entire disc, which will present the appearance of a circular opening, more or less clear and distinct. But if, after having thus brought the polarizer to make any angle whatever (except the zero degree) with $O\,A$, and leaving it fixed in the last position, the analyzer shall be turned to a slight angle, either to the right or to the left of $S\,P$, Fig. 5; then, immediately, the equality of shade of the two half discs is lost, one grows deeper and the other more clear; this sudden change allows the determination of the position of the analyzer with great precision, and of the position of the zero of the instrument, when there is no substance for examination interposed. If any substance possessing the rotary power be interposed, it destroys the equality of shade of the half discs; and upon turning the analyzer as much as is necessary to re-establish this equality, the angle of

rotation to which the analyzer has been turned, indicates the rotary power of the substance. In this way this instrument gives a very simple, general solution of the question. That is, the angle of the principal rays from each of the two halves of the diaphragm can be made variable at will, and this new optical combination permits the study of different angles easily and rapidly within the limits of comparison; and, finally, to determine which is best to be taken in the case under consideration.

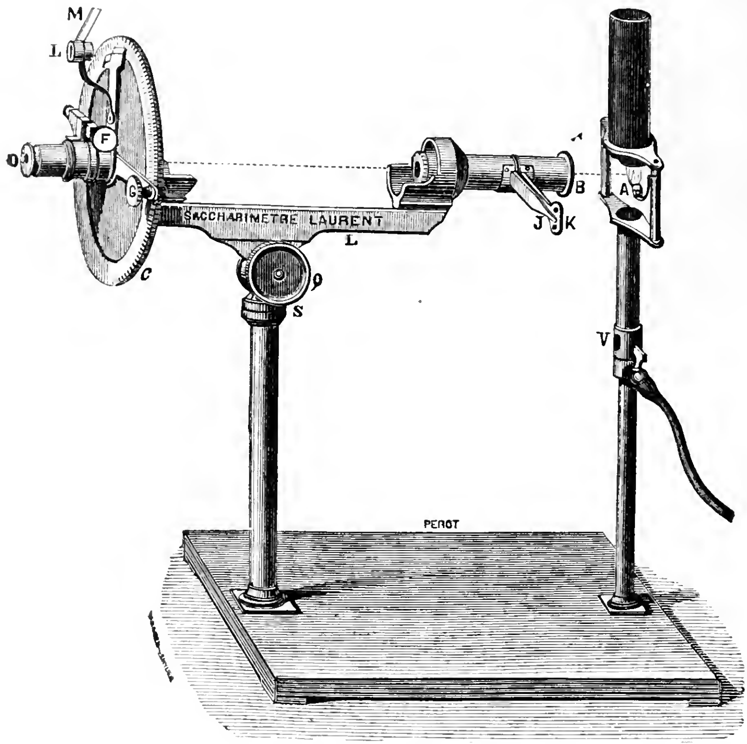

Fig. 6.

Fig. 6 is an elevation of the complete instrument in perspective. The reference to letters in description of Fig. 1, will explain more fully the purpose of the several parts; the parts not designated on Fig. 1 are: *G*, button for pinion to move divided circle; *F*, adjusting screw for vernier; *R*, tube containing the analyzer and object-glass, axis of motion effected by *F*; *Q*, button of clamp-screw, to give the horizontal adjustment of the instrument: *S*, pivoted axis, for allowing the instrument to be swung in a horizontal plane.

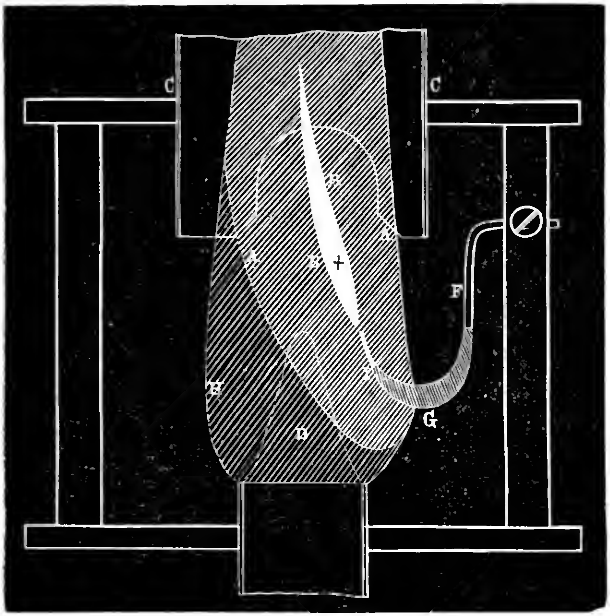

Fig. 7.

Fig. 7. *A*, yellow flame of ordinary burner; *B*, luminous part—supplementary and very intense; *C*, chimney, rendering the flame fixed; *H*, violet flame, high, large, and excessively hot; *D*, flame in the form of a cone, greenish and cold; *G*, *spoon* or *cup* of thin platinum plate, supported by a strong platinum wire, *F*. The burner *A* will operate with 0·08 to 0·12 in. of water pressure, and can also be used by partly closing the burner cock, with 0·4 inch pressure, so that the ordinary gas pressure will answer for this burner.

The position of the burner in place, for making an experiment, and the view of the several adjuncts, is shown on Fig. 6; but Fig. 7 exhibits an enlarged section of the flame, and serves to describe the manner of its operation. In the platinum cup *G*, Fig. 7, there is placed a grain of salt, which, when fused by the intense heat of the flame *H*, mounts, by capillarity, the length of the grooved strip or border *I*, which is very hot; and the vapor of salt produces at *B* a narrow flame, exceedingly brilliant, even more brilliant than is absolutely requisite in using the instrument. But little salt should be put in at a time, and the supply frequently made. When there is too much or too little salt in the cup, the intense luminous part of the flame is impaired. It is very essential, for obtaining the best results, to locate the cup at the place indicated on Fig. 7; that is, in the middle of the flame, but well under the side, the raised edge being in the violet flame. The purpose of the plate of bichromate of potash, *B*, Figs. 1 and 6, is to purify the yellow flame by absorbing completely the violet rays, as well as the blue and part of the green, which exist in the flames *D* and *H*, that proceed from gas burnt with a current of air; and it does this effectually, without taking up any of the useful yellow rays.

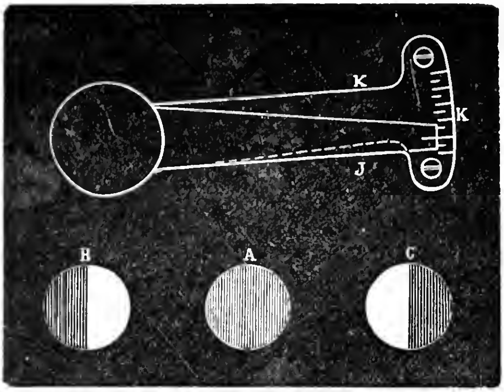

Fig. 8.

The operation of the instruments is as follows: The lever *K*, Figs. 6 and 8, being raised to contact with its stop; a tube, *T*, Fig. 1, of eight inches in length, filled with distilled or filtered water (not boiled), is placed in the instrument, and by means of the clamp button *Q*, Fig. 4, which is screwed up moderately, and the swing adjustment *S*, Fig. 4, it is directed against the flame *A*, as nearly as possible; (afterwards, this adjustment of direction is exactly made). The eyepiece *L* is adjusted so as to allow the division to be seen distinctly. These divisions should be well illuminated by the mirror *M*, which receives its light from the flame *A*, because it is preferable to operate in obscurity. The zero of the vernier is moved to about the 7th division in hundredths of sugar (or about $1\frac{1}{2}°$, if the scale of degrees is taken), either to the right or left; which motion is effected by means of the clamp screw *G*. Following this, the eyepiece *O* is looked into, and there should be the appearance *B* or *C*, Fig. 8; that is, there should be seen a disc, divided in two halves, the one clear, a bright yellow, and the other a yellowish black. The tube *O*, of the eyepiece, is drawn out or moved in, until the separation of the halves is nicely indicated, and the edges of the diaphragm outside of the disc do not appear. Later on it is very important to establish carefully the equality of shade; the better this is done the more sensitive or accurate will be the observations of the instrument. It is well to notice here, by way of testing this thin plate, while the edge is perfectly clear and sharp, that the two half discs are not separated either by a black line, or by a line black and white; they are rigorously tangents, and the least difference of shade between them is appreciated; when making an equality of shade (*A*, Fig. 8), they have no line of separation whatever. This detail has a great practical importance and certainly increases the relative sensibility of the saccharometer.

The instrument possesses in the two axes of rotation at *O* and *S*, the means of directing it towards the light. From time to time it

should be made certain that it is well pointed to the maximum of light and this adjustment must be carefully maintained.

Having thus disposed the instrument, the arm *L* is to be taken by the left hand, while the right hand is employed in holding the tube *R*, Fig. 6, between the thumb and index finger, when applying the eye to the eyepiece *O*, by little movements, up or down, to the right or to the left, the disc is brought to appear of the most uniform shade. The final adjustment is performed by use of the button *G*, which brings the zero of the vernier, to coincide with exactness to the division which may be chosen, after which the instrument is readjusted by means of the button *F*, which is provided only for this purpose, until the two sides will be seen (as at *A*, Fig. 8), of a gray yellowish shade, quite equal in intensity. [The button *F* turns in the reverse direction, as the dark side clears itself, or the light side becomes darker.] The exact place of equality of shade has been found when, by turning the button *G* alternately to the right or left, by little movements, there passes successively the appearances *B* and *C*, Fig. 8, when fixing the point of arrest definitely at the appearance *A*. The instrument is then adjusted for its zero point, but it should now be verified; for this displace the index by the button *G*, and by means of the same button reproduce the equality of the shades. If the adjustment has been carefully done, it will be easy, by regarding the traverse of the arm *L*, to re-find the zero of vernier in coincidence with the division. If otherwise a slight touch of the button *F* in one direction or the other, will produce the coincidence of zero, and allow the establishment of the equality of shades by means of the button *G*, and then only the instrument is well regulated for one operator *solely*.

The solution of sugar being interposed (in place of the water in the tube), the two sides of the Fig. 8 will become clearer, and at the same time more unequal in shade. The button *G*, Fig. 6, should then be turned in such direction, that the least clear side continues to become darker until nearly black; pursuing in the same direction this dark side shortly clears itself, and the clear side becomes black almost immediately; the proper point will then have been passed; on turning slowly backwards the equality of shade is established by a series of oscillations of the button *G*, becoming smaller and smaller as the appearance *B*, Fig. 8, changes to that of *C*, before finally stopping at that of *A*.

If the vernier has turned to the right in its departure from zero, the rotary power is right hand, as is given with cane or beet-root sugar, diabetic sugar, glucose, right hand quartz, etc. If the vernier has turned to the left, the rotary power is left handed, as exhibited by uncrystallizable sugar, inverted sugar, left hand quartz, etc.

Oftentimes in the industry of sugar, the juices or syrups are colored; these being placed in the instrument (the lever *K*, Figs. 6 and 8, being raised), are so dark, that nothing can be seen, and that it is thus impossible to do anything with them. The same obscuration occurs with other saccharometers. This instrument now offers a means for obviating this defect not possessed by any other, in permitting the passage of more light through it, by lowering gradually the lever *K*, as much as may be necessary. The enormous advantage of being able to use the saccharometer with an approximation sufficiently close for all purposes, in cases where all others fail, will be appreciated by those who have knowledge of, or use for, these instruments. It is possible to avoid in this way the effect of discoloration of liquor or syrup by bone-black, an operation heretofore long and subject to error, from the quantity of sugar retained by the black itself.

Any liquid being given, one can always, with this instrument, choose that angle which will give the best result, and practice shows that this angle varies with the coloration of the liquid. To effect this, the horizontal arm *J*, Fig. 8, has a point or mark, and the other, *K*, has divisions, forming a scale (in this instance in millimetres, but the size of the divisions are of no consequence, only that they had better been in degrees) to serve for indication of the movement, by which the best result for a certain coloration can be determined and made note of.

If it is desired to verify the result of any experiment, by another operator, it is necessary that the latter should re-make for himself all the manipulations, unless he has the same view or peculiarity of vision. It is sufficient to re-take the zero with distilled water and to examine and verify the equality of shades with the liquor.

The perfected burner which has been described, is not restricted in its use to saccharometers; but is also applicable in all cases where an intense monochromatic light is desired. Amongst other instances of this kind, its application to the spectroscope would be very happy. The saccharometer of Mr. Laurent (grand-son-in-law of M. Soleil) is an excellent practical instrument, which it is not known how to recommend too highly.

TOUGHENED GLASS:

Notes on its Manufacture.

From *The Practical Magazine* of London, for October, 1876.

[Continued from Vol. cii, page 374.]

Good management of the melting-ovens is of capital importance; the perfect homogeneity of the material is also one of the conditions of success. Glass that has remained a long time in the crucible, and that has thus maintained for too long an elevated temperature, tends to give way to a commencement of devitrification; in this state it will break in the bath. The work also should proceed rapidly and never be interrupted when it is desired to utilize the great part of the material contained in the crucible. A glass which presents a striated appearance—a defect likely to be produced if the management of the oven is not regular—will not adapt itself to toughening.

Apparatus for Toughening Table Glass.—The grease-bath is contained in a cylindrical iron tub, placed on the floor of the factory, and as near as possible to the working-hole. This tub is 0·75 m. high and 0·60 m. in diameter. For convenience in carrying, the height should not exceed that of the opening of the working-hole above the ground. The capacity, limited by the necessity of being able to easily displace the tub in the factory, should be sufficient for it to contain and toughen during two or three consecutive hours pieces of the least dimensions. If the tubs are placed at a depth in the ground, and made to move upon rails in trenches, their capacity and depth may be increased and at the same time their displacement rendered more easy. It is necessary for this to have the working-holes heated by furnaces independent of those that contain the crucibles, to which access must be entirely free. In the tub is fitted a basket of 0·50 m. high and 0·55 m. in diameter; this lining, being a wire trellis of large mesh, is elastic, and sustained by iron braces. It is into these baskets that the glass is thrown at the moment of toughening.

Manner of Toughening Table Glass.—The object being very uniformly heated, the workman takes it from the working-hole, plunges

it rapidly into the bath, and after detaching it from the pontil by a slight blow on the side with a piece of wood, it falls to the bottom of the wire basket. This operation demands great supervision, and on the part of the workman much care and attention. There are numerous precautions in detail to observe to avoid the malformation of the glass at the moment of immersion. These precautions vary with the form of the pieces, and each of them is a study in itself. Different apparatuses have been contrived to facilitate the operation.

A pouch of metal wire with a movable bottom is fixed inside the tub, and immersed from 0·30 m. to 0·35 m. in the liquid. Its use is to receive primarily those pieces which, by reason of their weight or of their form, might, by too brusque a fall, break the glass that is already at the bottom of the tub. There are some pieces, such as goblets, which are placed in the tub directly from the carrying rod without fear of breaking.

The toughening of water-bottles and similar vessels with necks presents a difficulty on account of the necessity of instantaneous introduction of the liquid into their interior. With the syphon a solution of this problem is found. The neck of the bottle is placed on the smaller branch of the syphon, which is elevated a half-centimetre above the surface of the bath. The confined air escapes by the tube, and the liquid takes its place, and at the same time, by a see-saw motion, the pieces fall to the bottom of the basket. A pump can be adapted to the syphon to extract the air from the bottle. By this means bottles with the narrowest of necks may be tempered. The toughening of objects made in several pieces has not hitherto been successful; the portions become detached in the bath.

Cooling, Cleansing, and Rinsing Toughened Crystal.—It is important to allow toughened crystal to gradually cool before removing it from the bath. To effect this, the tubs, placed on triangles, are removed from the working-hole and placed in a room in which a constant temperature of 40°—that of melting of grease—is maintained. In the course of four or five hours the baskets are taken from the tubs, and the pieces of glass taken out one by one and arranged to dry on sieves. The sieves are put into a stove, called the draining furnace, which is kept up to a temperature of 70°. In about two hours the glass is divested of the grease which had adhered to its sides. Taken from the stove, it is replaced in the large-mesh wire baskets, and these baskets are successively plunged into three

reservoirs—the first containing a bath saturated with caustic soda, and heated to 60°, the second containing water at 50°, the third, water of the temperature of the surrounding air. The glass, after it has been taken from the third reservoir, is perfectly rinsed; it is then dried, and taken to the warehouse, where it goes through a first sorting before being sent to the cutter. I will add here that toughened glass is cut and engraved more easily than ordinary glass.

When, instead of grease, a bath of oil is used, the pieces are allowed to cool longer before taking them to the tub; but the cleansing is much more expensive. They require to be treated with essence of turpentine.

Cost of Toughening Crystal.—The introduction of toughening into an existing glass-house is worked as follows for each furnace of three places:—1st. For staff, one more workman, called toughener, to each place; two porters to remove the tubs, and three men to take charge of the cleansing of the crystal. 2d. For plant, four tubs to each place, each containing 170 to 180 litres of grease; two or three pouches, and as many syphons; three iron reservoirs, of a cubic metre capacity, for cleansing and rinsing; a number of sieves and baskets for carrying the glass to the cleansing reservoirs.

A tub for toughening, with its accessories, costs from 100 to 120 fr.; grease costs 120 fr. for 100 kilogrammes. For a melting furnace of three places, comprising six crucibles to four working-holes, the expense of toughening crystal will amount in a month of 26 days to the sum of about 2,200 fr. That is:—

	Fr.
Six tougheners, at 150 fr. a month, . .	900
Two porters for tubs, at 130 fr. a month, .	260
Three men for cleaning, at 110 fr. to 120 fr. a month,	350
Loss of grease by evaporation and in the manipulation of the glass, ...	200
Fuel for the draining furnace, for the tubs for toughening and cleansing, ...	100
Soda for cleansing, ...	150
Wear and tear of apparatus and of the draining furnace, and interest on capital, . .	250
Total, ...	2,210

The loss occasioned by breaking and deformation of pieces in the bath is as yet of much importance, but every day will tend to dimin-

ish it with the improvements that may be brought to bear in the manner of toughening.

With these facts, knowing the exact number of pieces of the same model that can be made in a day's work, it will be easy to fix the price of the cost of toughening each object. Admitting 10 per cent. of loss and deformation, the price will be approximately :—

22—25	per cent.	for goblets of all shapes.
30	"	for gas glasses.
40	"	for lamp glasses.
50	"	for lamp globes.

Glass costs more to toughen than crystal—the glass being toughened in oil, and at a higher temperature, the loss of the liquid from evaporation is more considerable, and the cleansing of the pieces more expensive. The cooling of the bath being also more slow, continuous work requires a greater number of tubs to each place. Instead of four there should be eight or ten.—Translated from *Le Technologiste.*

Lectures on Technical Mechanics.—A course of lectures on this subject, intended to instruct practical men in the application of mechanical science to practice, will be given by John W. Nystrom, at the rooms of the Franklin Institute, on the Friday evenings of January, February, and March, 1877.

Mr. Nystrom will offer a course substantially like those given by Technological Institutions on the continent of Europe, in which he will commence at the beginning, and lead his hearers step by step to the higher applications of practical mechanics. "The only knowledge required on entering the course is simply arithmetic. The necessary geometry and algebra will be taught, together with mechanics, so as to enable students in the class to read understandingly scientific books on that subject."

No more useful course of lectures can be possibly offered to the practical workman, or to the amateur in mechanics, than this proposed by Mr. Nystrom, and it is hoped that he will have large and appreciative audiences. The tickets to the whole course are $3.00 each, for a single lecture 25 cts. They are for sale by the Actuary of the Institute, or at the door of the Lecture Room.

Chemistry, Physics, Technology, etc.

ON THE GROWTH OF THE

ALKALI AND BLEACHING POWDER MANUFACTURE OF THE DISTRICT OF GLASGOW.

By JAS. MACTEAR.

Paper offered to the British Association for the advancement of sciences. Read before the Chemical Section, September 12th, 1876.

INTRODUCTION.—It has been considered that a slight historical sketch of the rise of the Alkali and Bleaching Powder Manufacture of Glasgow (which indeed was the birthplace of the latter article) would fitly take its place in a report upon the chemical industries of the district, on the occasion of the visit of the Association at this time.

In the search after the necessary data, so many curious facts and figures cropped up, that indulgence must be craved for the length of the communication, which, even as it is, far from exhausts the subject.

PART I.—SALT.

Intimately connected with the manufacture of alkali and bleaching powder is that of common salt.

The heavy duty on this article at the end of last and beginning of this century retarded for many years the development of the alkali trade.

The following details regarding the salt manufacture are interesting:

In the year 1798 (previous to the rise of duty which came into effect in the summer of that year), the quantity of salt manufactured in Scotland was 350,000 bushels of 56 lbs. each, or 8750 tons, produced by 118 pans distributed as below :—

Division.	Situation.	Pans	Division.	Situation.	Pans
				Brought forward,	51
Aberdeen..........	Patsoy	1	Kircaldy	Kircaldy	2
"	Peterhead........	2	"	Dysart............	7
"	Nigg	2	"	Wemyss	7
Ayr	Maryburgh......	1	"	Methel...........	8
Alloa.......	Limekilns	1	"	Leven..............	3
"	Craigflowers.....	4	Montrose..........	Montrose.........	2
"	Torryburn........	1	"	Usan...............	1
Anstruther........	St. Phillips	7	Prestonpans.......	Prestonpans	6
Borrowstounness	Corly Hall........	7	"	Cockenzie	11
" ..	Thistone..........	7	"	Cuttle.	2
" ..	Grangepans......	5	"	Westpans.........	6
" ..	Inverkeithing...	4	"	Penkie pans.....	8
" ..	St. David's.......	4	"	Duddingstone ...	4
Irvine	Saltcoats	4			
Stranraer...........	Gladmock..	1	Total Pans......................		118
	Carry forward,	51			

Produced annually, 350,000 bushels at 56 lbs. each = 8750 tons.

From this it would appear that each pan produced annually about 75 tons, or say $1\frac{1}{2}$ tons per week.

The price was 3*s.* 3*d.* per bushel or 6*l.* 10*s.* per ton, duty inclusive, the latter being 1*s.* 6*d.* per bushel or 3*l.* per ton.

The additional duty now put on was 6*s.* 6*d.* per bushel or 13*l.* per ton, making the cost amount to 19*l.* 10*s.* per ton.

The duty in Scotland was much less than in England, the figures being in the year 1805—Scotland, 12*l.* per ton; England, 30*l.* per ton.

The following is a statement of the method and cost of manufacturing one ton of salt, dated September, 1806:—

"At Mr. Cunningham's works at Saltcoats there are in operation "4 pans, each 18 ft. by 9 ft. by 1 ft. 9 in.; each pan requires three "men, or twelve in all.

"These men are paid at the rate of 1*s.* 1*d.* per cwt., exclusive of "house and fire.

"They keep their fire-places in order without any allowance, re-"pairing them with schistus or clay, got in the immediate neighbor-"hood. The schistus answers for brick, and they say much better. "They are not allowed for the time lost in repairing their boilers.

"The pans are of malleable iron of nearly $\frac{3}{8}$ in. thick, supported "on malleable iron bars about 3 in. square, placed across under each "row of clink nails, say about 15 in. apart.

" A pan, with frequent repairs, lasts about five years, and costs " when new about 200*l*.

" These pans yield five castings of salt per week, weighing 10 to " 11 cwts. each, agreeable to the strength of the sea water.

" In order to produce these 10 to 11 cwts. of salt, the pan is filled " three times till within four inches of the brim (they cannot be filled " more with advantage to the ebullition).

" The two first fills are boiled down till the salt begins to form, the " first down to within about one inch of the bottom, the second to " within about one and a half inches, and the last to about two and a " quarter inches, which consists chiefly of the pretty dry salt.

" This salt is then raked to the side of the pan, and thrown into a " square chest, where it is allowed to drain till a third casting is " ready to replace it, two chests being always employed.

" While in this situation it yields about 20 gallons of bittern, or " 'pan oil,' as the workmen call it.

" In each pan there are four small round vessels of 8 in. by 4 in., " placed one in each corner, which, during the evaporation, collect " all the insoluble salts and impurities deposited during the process, " sometimes more or less, in proportion, it is said, to the weakness of " the water.

" *State of Charges by the ton weight.*

" Wages, ...	£1	1	8
" Coal dross, 162-192, say 180 cwts., at 1*d*.,	0	15	0
" Tear and wear, say, ...	0	10	0
" Rent, say, ...	0	4	0
" Cartage of coals, at ¼*d*. per cwt., . .	0	3	9
	" £2	14	5 "

The manufacture of salt is still continued at Saltcoats, but on a different system, the sea water being employed to dissolve rock-salt obtained from Ireland, which gives a solution requiring much less evaporation than the old system.

This method is also carried out to a small extent in Glasgow.

The following table gives the prices of salt for chemical purposes in Glasgow from the year 1798:—

Year.	Price per ton.	Year.	Price per ton.
1798, . .	£13 to £18	1803, . .	£12 0 0
1800, . .	£12 0 0	1804, . .	12 0 0
1801, . .	No details.	1809, . .	19 0 0
1802, . .	"	1814, . .	11 0 0

Year.	Price per ton.	Year.	Price per ton.
1819, . .	£1 12 0	1849, . .	0 17 0
1824, . .	2 6 0	1854, . .	0 15 0
1829, . .	1 2 0	1859, . .	0 16 0
1834, . .	0 19 0	1864, . .	0 14 0
1839, . .	1 1 0	1869, . .	0 14 6
1844, . .	0 16 0		

At or about which price it has since remained.

The quantity of salt used for chemical purposes previous to the introduction of the method of bleaching by chlorine, must of course have been small. Marine acid, however, was made, and there is a tradition amongst the oldest workmen of the chemical works that it was produced (some years previous to the introduction of sulphuric acid about 1749) by the distillation of salt and earthy matter. That this process was actually in use is extremely probable, as it is described by the writers of the last century—"eight parts of clay or bolar earth to one of salt" being the mixture recommended, distilled in stoneware retorts.

Part II.—Sulphuric Acid.

The substitution of dilute sulphuric acid for sour milk in the old system of bleaching, which had the effect of reducing the time required by nearly one-half, gave rise to a demand for vitriol in considerable quantity, and to supply this demand a work was erected in 1749, at Prestonpans.

I have been unable to find any evidence of the manufacture of sulphuric acid in Scotland previous to this date.

As is well known, the first method of producing sulphuric acid was by the distillation of sulphate of iron or *green vitriol.*

This was followed by a method of burning sulphur under a bell glass moistened with water, and the acid (produced in very small quantity) is said to have been sold at 2*s.* 6*d.* per oz.

In 1740, MM. Lefèvre & Lémery proposed the addition of nitrate of potash to the sulphur, and suggested that the combustion could then be carried on in closed vessels. This idea was taken up in England by a Dr. Ward, who used large glass vessels holding about 300 litres, and containing at the bottom a small quantity of water.

A small capsule, supported on a stoneware stand, was charged with a mixture of one of nitre and eight of sulphur. This was set on fire and the neck of the vessel closed. After the combustion had ceased, fresh air was allowed to enter the vessel, and these operations were

repeated until the acid was sufficiently strong for concentration in glass retorts. This acid sold at about 2*s.* per lb.

Dr. Roebuck of Birmingham improved on this process by erecting a leaden vessel of about 6 ft. square as a substitute for the glass ones previously in use. This was in 1746, and works were erected by this gentleman and a Mr. Garbett, in the year 1749, at Prestonpans, on the east-coast of Scotland.

This, then, was the beginning of the sulphuric acid manufacture in Scotland. Other works were soon erected, and in 1797, there were in Glasgow alone at least six or eight different works.

In this year the question of the strength of the commercial vitriol seems to have received a good deal of attention, and a set of hydrometers were invented or arranged by a Mr. Foy, a chemist at that time engaged in bleaching operations.

The following is a note of the cost of manufacturing 950 bottles of vitriol (of 150 lbs. each).

"*Mr. M——'s business*, 1798."

25 tons Sulphur—say at £40,				£1000	0	0
7 " Nitre " 100,				700	0	0
Coals,				105	0	0
Wages and houses for men,				250	0	0
Tear and wear of utensils,				30	0	0
Rent and buildings,				70	0	0
Cartages,				40	0	0
				£2,195	0	0
142,500 lbs. O.V. at 6½*d.*,	£3.859	17	6			
Less discount at 10 per cent,	385	19	9			
				3,473	17	9
Profit,				£1,278	17	9

This gives nearly 64 tons of acid costing, say £32 per ton, and selling for, say £54 net cash.

Description of method of working then in use by Messrs. Bealy, Radcliffe, near Manchester :—

May, 1799.—" There were six chambers, 12 ft. by 10 ft. by 10 ft.,
" roofed like a cottage. They were placed in houses having openings
" in the brick walls, leaving the lead to be exposed to the atmos-
" phere.

" This is perhaps of more use in expediting the filling of the cham-
" bers with fresh air than in aiding condensation. Mr. Laird (a
" Glasgow manufacturer of the period) says that the hotter the
" chambers are kept the condensation is the more perfect.

" Each of these chambers has a valve, which is opened between the
" burnings.

" In them there are burned each week 1386 lbs. sulphur and 198 lbs.
" nitre, burnt in double pans, the larger above the lesser, and yielding
" 1800 lbs. of O.V. of 1·8 sp. gr. (equal to a produce of 130 per cent.
" on sulphur, with 14.28 per cent of nitre).

" Eight to nine inches of water on the floor of the chamber.

" The sulphur and nitre are mixed in the proportion of one of nitre
" and seven of sulphur.

" Of this mixture 8 lbs. are burned in each chamber every four
" hours. The mixture is burned on iron plates or trays, of which
" there are two sets only in each chamber (more not being found so
" productive), each set consisting of two plates, one placed over the
" other, about 3½ inches apart.

" The iron is of best quality and very thin, so that they heat
" quickly. They are supported on a frame, which can be drawn out
" at the door of the chamber.

" One pound weight of the mixture is put upon the lower plate, and
" three pounds on the upper plate.

" The plates being charged, the lower plates are first ignited, and
" when fairly lit, then the upper plates; the frame is then pushed
" into the chamber and the door shut.

" The whole will be finished burning in one hour.

" Charge again three hours after the burning is over, or once every
" four hours, opening the doors and valves a quarter of an hour be-
" forehand.

" The plates to be cleaned each time.

" By keeping this going on, they in six weeks make their O. V.
" attain a gravity of 20 oz. (1·250 sp. gr.), when it is run off for con-
" centration to 22 oz. (1·375 sp. gr.), when it is used for bleaching
" liquors, etc., etc.

" Having six chambers, therefore affords one for drawing off each
" week.

"*State agreeable to the above.*

"1386 lbs. Sulphur, at £22,	£13	12	3
" 198 " Nitre " 64,	5	13	1½
"Labor,	1	1	0
"Tear and wear,	1	1	0
	£21	7	4½
"Off for drawback on sulphur, at £6 12 8 per ton,	4	2	0½
"Producing 1800 lbs. O V., costing,	£17	5	4

"Equal to 2⅓*d.* per lb. or 21*l.* 10*s* per ton.

"Interest on sunk capital omitted in this state."

The prevalent theory held at this time may be seen from the subjoined note.

"When sulphur is heated to 302°, it burns with a blue flame, and "the produce is chiefly sulphurous acid.

"When sulphur is heated to 570°, it burns with a white flame, and "the produce is sulphuric acid."

Numberless experiments were conducted with the view of being able to burn the sulphur at the proper degree of heat which should yield only sulphuric acid.

The fact that a quantity of nitrate of potash only equal to one-eighth of the oxygen required was sufficient for practical purposes, seems to have given rise to the most extraordinary ideas at this time.

The following calculations give a good illustration:—

"100 of nitrate of potash according to Kirwan, contains 41·2 of "nitric acid, 46·15 potash, and 12 83 water.

"The acid of nitre consists of 7 of oxygen and 3 of azote, hence "100 nitrate of potash contains 28·7 of oxygen.

"100 of sulphur, it appears from Kirwan, requires 140 of oxygen "to saturate it, or convert it all into sulphuric acid.

"100 acid, therefore, consists of 41·67 sulphur and 58·33 oxygen.

"Consequently 100 sulphur would require the oxygen of 525 of "nitrate of potash for complete saturation.

"When, therefore, the maker of sulphuric acid adds 10 of nitre to "100 of sulphur, he has only 2·8 of oxygen, which will saturate only "2 of sulphur.

"Now 10 of nitrate of potash contains 4·612 of alkali; that alkali "is converted into sulphate of potash, and requires for this 4·5 sul-

" phuric acid in that state in which it exists in the sulphate of potash " (it contains, by Kirwan, 45 acid and 55 potash). *That is, the potash " of the nitre takes more acid than is produced by the oxygen contained " in the nitre with its proper proportion of sulphur.*

" The nitre, therefore, used in the manufacture of sulphuric acid " does not produce *any* acid which the manufacturer can be the better " of. It produces no sulphuric acid in an uncombined state. The " only other purpose it can serve is to produce such rapid inflamma- " tion of the sulphur as will be productive of sulphuric instead of " sulphurous acid; *that is, it produces a white flame, and the temperature " of* 570°.

" Even with nitre, a great deal of blue flame is present, and con- " sequently much sulphurous acid formed, and this sulphurous acid is " all lost to the manufacturer, as it flies off in the operation.

" The manufacturer, at most, produces from 100 sulphur, 168 of " marketable oil of vitriol of 1·846 sp. gr.

" But 100 parts of sulphuric acid at this strength is equal to 89 at " 2 000, which Kirwan calls his standard acid, and 100 standard acid " is equal to 89·25 of acid, such as exists in sulphate of potash, or 100 " parts acid at 1·846 sp. gr. are equal to 78, as existing in sulphate " of potash.

" The manufacturer therefore only gets 125·6 acid, such as exists " in sulphate of potash, whereas 100 parts sulphur should produce 240 " parts of such acid, deducting 2 parts, which go to form the sulphate, " leaving 238 parts.

" These 238 parts are equal to 290 at 1·846 sp. gr., which ought " to be the produce, instead of 168.

" Hence only 55 parts of the 100 sulphur used, go to form sulphu- " ric acid, and 45 parts are lost.

" Some part of these 45 may indeed be impurities—allow 5 per cent. " on this account—still the manufacturer loses 40 parts in every 100 " of sulphur.

" These 40 parts are converted into sulphurous acid, and are lost."

The only way to prevent this is to burn the sulphur with a white flame, and by raising the temperature in which it is burnt to 570°.

At the Prestonpans Works in 1800, *they used, per* 112 *lbs. of O. V.:—*

100·8 lbs. of Sulphur, at 7*s*., . .	£0	6	3
13·06 " Nitre, at 36*s*., . .	0	4	2
All other expenses, ...	0	10	7
Cost delivered to purchasers, .	£1	1	0

The selling gross price being about 60*l*. per ton. This is equal to a production of—say 198 per cent. acid, 1·84 sp. gr., with 13 per cent. nitre.

The size of these chambers was most likely the same as given in 1813, when they had 108 chambers, 14 ft. long, 10 ft. high, and 4½ ft. wide. In 1805 a work existed at Burntisland which employed no less than 360 chambers, each 8 ft. long, 6 ft. high, and 4 ft. wide, containing 192 cubic ft. each.

Water equal to 70 or 80 gallons (5 to 6 inches) was run on the bottom, and the charge was 1 lb. of a mixture of 1 nitre to 6 of sulphur every four hours, half an hour allowed for ventilation.

The burning was continued for ten weeks, in which time 36 chambers yielded 60 bottles rectified acid. This being the weekly produce of the works:—

Produce, . .	173 per cent. O.V. 1·84 sp. gr.
Nitre, . .	16 6 "

Many more such details might be given, but it will be more instructive to trace the development of this manufacture in the progress of the St. Rollox Chemical Works.

These works were erected in 1799, for the production of bleaching powder, a patent for which had been secured by Mr. C. Tennant in the previous year. Considerable quantities of sulphuric acid were required for this manufacture, and were purchased from the various local makers, from the Prestonpans Vitriol Company, and supplies were even brought from Halifax.

The price at this time being about 60*l*. per ton delivered.

The consumption increasing rapidly, chambers were erected at St. Rollox in 1803; these were six in number, and seem to have been 12 ft. by 10 ft. by 10 ft., costing to erect about 50*l*. each.

The house in which they were contained was of three floors, about 50 ft. long by 24 ft. wide—the upper contained the chambers, the next the glass retorts for concentrating the acid, and the lower the leaden evaporating boilers used in bringing the acid up to strength for the glass retorts.

The system upon which these chambers were worked, was that as already described as in use by Messrs. Bealy, and the quantity of sulphur burned was about 1000 lbs. weekly, with about 14 per cent. nitre.

Various modifications of this system were tried, chiefly to improve the yield by charging less often, until the question of how to deal with the residues became a serious one, and in 1807 a third plate was added, on which the residues, or "sulphur ashes," were reburned, mixed with a little fresh nitre.

This succeeded so well that considerable quantities of these residues were purchased from the other makers over the country, and used up in this way.

These sulphur ashes contained from 25 to 50 per cent. when only once burned, and cost about 5*l.* per ton.

At the end of this year, a brick furnace, heated artificially, was attached to one chamber, and in a short time two chambers were attached to one furnace, which was placed between them and had a flue to each chamber.

The furnace burned the sulphur ashes mixed with a portion of fresh sulphur and nitre. It worked almost continuously, the gas passing into one chamber for a certain time, the other meanwhile being shut off by means of a damper, then the first chamber damper was closed and the second opened. No. 1 chamber was allowed to condense for some time, and then the air valves and doors were opened to let in a fresh supply of air.

There were 14 chambers at work in this year, during which a produce of about 200 of acid of 1·84 sp. gr. seems to have been obtained from 100 sulphur with 15 per cent. nitre. At the end of 1809, there were in operation 26 chambers.

In 1811, furnaces heated externally were applied to all the chambers, which were increased in number to 32, arranged in sets of two or three each.[i]

Sulphur ashes were used in large quantity.

The strength of the chamber acid, which had hitherto only been about 50° to 60° Twaddell, was gradually raised, and steam having been introduced about 1813 or 1814, a strength of 100° to 120°

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[i] Red-hot plates of about a foot square and ¾ inch thick in use generally by other makers.

Twaddell was attained, and the process became more or less a continuous one.

From this time till about 1840, the changes in the manufacture were chiefly in the direction of improving the form of the apparatus, both in chambers and furnaces.

Pyrites was first used in 1840.

Communications with Hill, show that he was using pyrites in 1820 in a chamber of 50 in. by 26 in. by 22 in.; and Gay Lussac's method of recovering the nitrous compounds by absorbing them in strong vitriol, in 1844 introduced by a Mr. De Courcy.

This was followed almost immediately by Mr. C. T. Dunlop's method of manufacturing bleaching powder by the decomposition of a mixture of salt and nitrate of soda, which gives off a mixture of chlorine and nitrous acid. The latter is absorbed in strong vitriol and used as the source of nitrous acid in the chambers.

Various methods of denitrating this nitrous vitriol were from time to time tried, and the most successful perhaps prior to the introduction of the Glover tower, was a wall of coke extending across the chamber, through which all the gases had to pass while it was kept supplied with nitrous vitriol at various points so as to expose it in as thin films as possible. This method worked extremely well for many years.

The methods now in use in the manufacture at these works differ but little from the general system in use by the other large manufacturers of Great Britain.

The following list of vitriol makers in England is interesting, compiled in 1820.

Name.	Situation of works.
Brandrum & Co., ...	London.
Farmer, ...	"
Smith, ...	"
Hill, ...	"
D. Taylor & Sons, ...	"
Liddiard, ...	"
Dobbs, ...	"
Skey & Beudley, ...	Staffordshire.
Caves & Co., ...	Bristol.
Bush, ...	"
Dobbs, ...	Birmingham.
Austen, ...	"

CHRONOLOGY—SULPHURIC ACID—GLASGOW, &c.

WORKS.	DATE.	No. of Chambers.	Length	Breadth.	Height	Method of Burning.	Produce from 100 Sulphur, @ 1·84 sp. gr.	Per Ct. Nitre.	Cost per Ton.	REMARKS.
			Feet.	Feet.	Feet.					
Mr. M——'s Business	1798	...	...	...	...	On Plates.	200 ?	28	£32	25 tons Sulphur, strength of acid unknown if 148°, yield would be 200 per cent.
Bealy's..................	1799	6	12	10	10	do.	130	14¼	£21 10s.	Cottage roofs—run off each 6 weeks.
Prestonpans.	1800	108	14	4½	10	do.	198	13	£21	Cost delivered to customers—run off in 10 weeks.
Burntisland...........	1805	360	8	4	6	do.	173	16·6	...	Cost not known.
Nisbet....................	1805	...	...	...	...	... ...	187	25	£29	Small work.
A. W. & Co...........	1805	6	...	...	...	... ...	187	19	£28 15s.	
W. N	1811	...	...	...	...	... ...	200	23	...	Sul. ashes re-burnt on red hot plates
Prestonpans...........	1812	108	14	4½	10	... ...	220	Not known	...	do. do. do.
do.	1813	108	14	4½	10	... ...	...	...	...	400 to 500 glass retorts at work 2 charges pr. wk. Chambers in 9 sets of 12 each, 1 set run off each wk.
Kenny, Dublin........	1813	2	45 25	17 17	10 12	... ...	...	...	...	
J. L——d.............	1813	...	...	...	...	... ...	200	20·8	...	
Camlachie..............	1820	...	...	...	...	... ...	263*	13	...	*Acid strength, supposed, 144° Tw.
Port-Dundas..........	1824	1	70	18	...	... ...	246*	...	...	* do. do. do.
St. Rollox..............	1803	6	12?	10?	10?	... ...	...	14	...	
do.	1806	...	...	...	...	... ...	185	12	£20 13s.	
do.	1807	...	...	...	...	... ...	193	15¼	£18 15s.	
do.	1809	26	No Record			... ...	...	...	...	
do.	1811	32	60?	14?	12?	Furnace.	...	...	...	

Name.	Situation of works.
Phipson,	Birmingham.
Paton,	"
Bower & Sons,	Leeds.
Norris & Son,	Halifax.
Betson,	Rotherham.
Doubleday, Easterby & Co.,	Newcastle.
Rawson & Sons,	Bolton.
Do.,	"
Watkins,	Manchester.
Mutrie & Co.,	"
Do.,	Whitehaven.

23 works in all at this date.

Part III.—Bleaching Powder.

It was in the year 1785 that Berthollet discovered the bleaching action of chlorine; he showed the experiments to Watt in 1786, and he on his return to Glasgow actually bleached a considerable quantity of linen by means of a solution of chlorine in water.

In the following year a work was established in Aberdeen by Professor Copeland and the then Duke of Gordon, for the production of solution of chlorine, which they supplied to the neighboring bleachers.

The injurious effects of the chlorine both on the workmen and on the goods caused the introduction of a portion of potash to the water, which had the effect of retaining the chlorine.

This method was extensively adopted by bleachers all over the country; the solution, however, did not keep well.

In 1798, Mr. Charles Tennant (then engaged in bleaching operations at Darnley) patented the use of lime instead of potash, and in conjunction with Mr. M'Intosh and others, began the manufacture of "lime bleaching liquor." They also granted licenses to bleachers, giving the right to manufacture it for themselves. The method was most successful, but the patent was disputed and declared untenable.

Mr. Tennant, however, in the following year patented a method of producing a dry compound of lime and chlorine, which, long known as Tennant's bleaching salt, and more recently as bleaching powder, has completely revolutionized the process of bleaching.

Works were erected for the manufacture of this article at St. Rollox in the same year.

It was prepared originally by the decomposition of a mixture of salt, manganese and sulphuric acid, in a leaden still heated by a

water bath, and the chlorine was absorbed by lime (slaked and sifted) in a leaden receiver, the lime being agitated from time to time by means of a stirrer.

The proportions used in the beginning of the year 1800 were:—

Vitriol, ...	4
Manganese, ...	2
Water, ...	4
Salt, ...	$4\frac{1}{2}$

These proportions were altered from time to time, and muriates of potash, lime and magnesia were tried, with a view of obtaining by-products of greater value.

The question of the utilization of the by-products was one which became very serious indeed as the production increased, and in 1803 the question was solved for the time by the production of an impure soda or black ash from the still residuums.

As the demand became greater, various methods were adopted to increase the production, and finally the system of stone stills, heated externally by means of steam, was adopted.

In 1823 the use of muriatic acid prepared from salt was employed. At first the process was tried with manganese in a separate vessel, through which passed the muriatic acid driven off from the salt. Very soon this was abandoned for the method now in use of condensing the acid in water, and using it in the liquid state.

The salt was at first decomposed in iron cylinders, and the condensers were cylindrical and of earthenware.

The condensing arrangement of Mr. Gossage was adopted soon after its introduction to the trade, and has been most successful at these works, which, indeed, are laid down with the object of utilizing the muriatic acid to the utmost—the loss of muriatic acid being now (1876) under 1 per cent.

Within the last few years there have been erected in the district three works for the production of this article in connection with the alkali manufacture, viz., those of Messrs. Orr and Brown and Henderson, both at Irvine, and Messrs. Arnott Bros., Kirkintilloch.

The method of manufacture devised by Mr. C. T. Dunlop is still a specialty at the St. Rollox Works.

It consists in decomposing a mixture of nitrate of soda and salt with sulphuric acid. This yields a mixture of nitrous acid and chlorine gases, with traces of muriatic acid.

The nitrous acid is separated by absorption in strong sulphuric acid, the muriatic acid by water, while the chlorine passes on to the bleaching powder chambers to be absorbed by the lime.

An idea of the progress of the bleaching powder manufacture may be had from the following table :—

Table of Prices Realized.

Year.	Tons.	Price.
1799–1800	52	£140 0 0
1801	96	130 0 0
1802	72	112 0 0
1803	Not known.	
1804	131	112 0 0
1805	147	112 0 0
1810	239	93 0 0
1815	377	81 0 0
1820	333	60 0 0
1825	910	27 0 0
1830	1447	25 0 0
1835	2122	22 0 0
1840	2383	26 0 0
1845	3861	16 0 0
1850	5719	14 0 0
1855	6260	11 0 0
1860	7459	11 0 0
1865	8431	10 10 0
1870	9251	8 10 0

(To be continued.)

Disinfectants.—(*Dingl. polyt. J.*, ccxix, 375.)—*Potassium permanganate* solution does not cause the death of infusoria for a long time. The spores of *Mucor* and *Penicillium* grow in strong solutions of this salt. Bacteria are killed by concentrated solution, but they increase in solution of 1·1000. When meat is placed in a solution of this salt, it is permeated with the liquid, but the action results in a decomposition of the permanganate, after which the meat is acted on by bacteria, etc. Permanganate may be advantageously employed for washing wounds; for disinfection of decaying matter it is, however, useless.

Dry *chlorine* is without action on the lower organisms; attempts to disinfect clothes, etc., by fumigation with chlorine are therefore useless.

Phenol quickly kills all lower organisms; it is, therefore, one of the best of all disinfectants.

Heat kills many of the lower organisms. Hot steam and water may become good disinfectants. M. M. P. M.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS DURING THE LAST TEN YEARS.[1]

By Dr. A. W. Hofmann.

From the *Chemical News.*

Continued from Vol. cii, page 432.

As it appears that the workmen do not make use of the respirators with which they are furnished, and at most merely tie a cloth over the mouth and nose when decanting large quantities of bromine, the most important point is to secure an efficient ventilation in all parts of the works. By attention in this respect, combined with the above-mentioned dietetic regulations, it has been found practicable to maintain the health of the workmen at Stassfurt, during the eight years of the existence of the bromine manufacture, so long as they refrain from the use of spirituous liquors (Frank).

(The editor of this Report has had opportunity during a recent excursion to Stassfurt to visit Frank's bromine works, and, it may be permitted him, to add certain results from his own observation in order to complete what has above been given in bold outline.)

The distillation of bromiferous mother-liquors with manganese and sulphuric acid is conducted in large cubic stone vessels made in one piece, and belted with iron bands in case of a fracture. Their average capacity is 3 cubic metres. At some distance from the bottom is a perforated plate of the same kind of stone, upon which the manganese is placed in fragments of the size of a nut. The stone trough is covered with a heavy plate of the same material, which is raised and lowered by means of a rope with a counterpoise playing over a pulley. In this cover there is introduced a thick stoneware pipe for the introduction of steam; and it is also provided with a man-hole, an aperture for pouring in the bromiferous liquid and the dilute sulphuric acid, and an opening for the escape of the bromine vapors.

Few stones are suitable for the construction of these vessels, and when the bromine manufacture was introduced at Stassfurt there was great difficulty in finding a suitable quality. Almost all the

[1] "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

stones tried experimentally after a time allowed the chloride of manganese to ooze through, and required to be coated with tar to overcome this defect. This, however, gave rise to a new inconvenience, considerable quantities of bromine being lost by the conversion of the hydrocarbons of the tar into bromine compounds, and the bromine itself becoming contaminated. Dr. Frank estimates the loss for every new coating of tar at about 50 kilos. of bromine. Latterly a kind of stone has been found in the neighborhood of Porta Westphalica which does not require this costly preparation and can be used at once. Still the high price of these stone troughs has given rise to attempts to manufacture bromine stills with large plates of slate, cramped together with iron bands and screws. A final decision has not yet been obtained.

The bromine lyes are kept in a large reservoir situate above the stills, in which they can be preliminarily heated by means of a coil of steam pipe. The height of the liquid is indicated by a float to which is attached a cord passing over a pulley and supporting at its other extremity a weight suspended in front of a scale, so that the workman in charging the stills is guided by the movements of this weight.

The stone lid is closed by its own weight, but may be further loaded with extra weights; the joints are made good with plastic clay. As we have already mentioned, the cover is raised by means of a counterpoise, but only when the apparatus is filled anew with manganese. The charge is about 4 cwts., which quantity serves for an entire series of operations. Not all qualities of manganese are fit for this purpose, that of medium hardness being the most suitable. The charges of bromine liquor and of sulphuric acid are introduced through one of the small apertures in the stone cover, which is immediately afterwards closed with balls of clay held down by iron weights. As soon as the apparatus is thus suitably secured steam is turned on and bromine vapors immediately escape in abundance through the leaden tube cemented into the second aperture in the cover. This leads to a worm surrounded with cold water in which the bromine is condensed. The original leaden worms have long ago been replaced by a stoneware apparatus.

At first the excellent but very costly stoneware worms of the English establishment "Lambeth Potteries," were used, but latterly German apparatuses have been employed, especially those furnished by

the firm of Jannasch, in Bernburg. The lower end of the stoneware worm opens by means of a bent glass adapter into the central tubulure of a large three-necked Woolff's bottle holding about 8 litres, in which bromine and bromine-water collect. Into one of the lateral necks is fixed a movable glass syphon, by means of which the bromine-water can be drawn off into stoneware jugs. From the other neck a bent glass pipe passes down to the bottom of an iron vessel, which widens upwards in a conical shape and which is filled with water and iron turnings. Vapors of bromine which have not been condensed in the bottle are arrested by the iron. The impure chloriferous bromide of iron, as well as the bromine-water syphoned off are returned to the stills for the next operation.

At the beginning of the process scarcely anything but bromine is evolved, afterwards chloride of bromine escapes, and ultimately, when there is no more bromine in the apparatus, pure chlorine is evolved. Dr. Frank, for the instruction of the author, kindly caused an operation to be carried to the very end so that the three stages of the process, which are easily distinguished by the color of the gas in the glass adapter, were fully exhibited. In the ordinary routine of the works the operation is stopped when the chloride of bromine begins to be given off. The workmen in these establishments receive in addition to their wages a premium on the quantity of bromine obtained. Hence it is their interest to get through the greatest possible number of operations, and as the bromine lye is on hand in abundance they break off the operation as soon as the distillation of the bromine slackens. The quantity of sulphuric acid also is so calculated that it only just suffices for the liberation of the bromine in a charge. Hence the bromine obtained ought to be free from chlorine. It is found, however, in practice that, on account, doubtless, of the imperfect mixture of the reagents, chloride of bromine is evolved even in the earlier stages of the distillation. The quantity of acid (hydrochloric acid?) must also be noticed, which is given off towards the end of the process and produces such an evolution of hydrogen in the iron vessel that its contents froth strongly. In order to prevent loss by running over, a broad saucer-shaped rim is cast on the iron at the distance of some centimetres from its upper margin in which the overflow collects and is conducted away by a side tube into a stoneware jug.

Each operation takes up about two hours and yields from 2 to 2·5 kilos. of bromine. The two bromine works at Stassfurt are so

arranged that they are capable of producing 500 kilos. in twenty-four hours, but this quantity has never been actually furnished.

The arrangements for the ventilation of the bromine works are peculiarly interesting. The critical moment is when the manganese liquid is run out of the stone tanks, since it throws off vapors of chlorine and bromine in abundance. Yet the operation is performed without the lest inconvenience to the workman. Along the series of stills there runs a channel of brickwork, through which a powerful current of air is drawn by the great chimney of the works in a direction opposite to that in which the liquid runs off. The channel is situated so that the vent holes of the stills open into it. In front of every still there is introduced in the roof of the channel, a damper which is opened when the plug of the vent hole is about to be knocked out. The draught is so powerful that the workmen are not in the slightest degree incommoded by the vapors evolved from the stream of solution of manganese. The workshops smell distinctly of bromine, but the odor is far fainter than that which is experienced in our scientific laboratories during the bromation of organic substances.

As has been already remarked, crude bromine always contains a little chlorine, even when, according to the Stassfurt practice, the Woolf bottle is allowed to become slightly warm towards the end of the operation, so as to drive the volatile chloride of bromine over into the iron-turnings. A rectification is therefore requisite. This takes place in glass retorts containing about 15 litres, the necks being cemented into receivers bedded in cold water. Each retort is set in a separate sand-bath, so that if one happens to burst—and such misfortunes cannot be avoided—the injury may be limited as much as possible. Only a slight aqueous fraction contains chlorine; it is withdrawn and returned to the stone stills. The rectification lasts about twenty-four hours. The atmosphere in the rectifying-house is more offensive than that in the still-houses, since all currents of air must be carefully avoided. The workmen, however, require to enter this room from time to time. Moreover there are especial arrangements which render it possible to decant the bromine both out of the Woolf's bottles into the retorts, and from the receivers into the vessels used for transport without any annoyance from the vapors abundantly evolved during these operations. The decantation is performed in wooden chests, through which a violent current of air is drawn by the great chimney. The workmen soon acquire such dexterity and

accuracy in these manipulations that they are content to cover the respiratory organs with a wet cloth, and disdain to make use of the ventilating arrangements placed at their disposal.

(At Stassfurt, bromine is sent off in strong glass bottles holding 2·5 kilos. The well-ground stoppers are sealed with shellac, luted with clay, and tied up with parchment paper. Four or twelve such bottles are packed in a chest.—A. W. H.)

Iodine.—The rapid extension in the demand of the splendid violet, blue, and green coal-tar colors, which are prepared by means of the iodides of the hydrocarbons, has in the last few years occasioned a notable increase in the consumption of iodine. The production, from very simple reasons, could not keep pace with the growing consumption, which of course led to a considerable increase in the commercial value of a body relatively of such rare occurrence in nature. Its price has been further increased by the circumstance that the seaweed ashes of England and France (Kelp, Varec) have become less remunerative to the producers. Formerly these weed ashes served to supply a considerable part of the demand for the salts of potash, but since the utilization of the well-known "Abraum salts" of Stassfurt the extraction of potash salts from seaweed ashes has become so unremunerative that the loss in the returns of the kelp trade has to be balanced by a rise in the price of the iodine.[i]

The hope of a fall in the commercial value of iodine in consequence of its extraction from the mother-liquors of nitrate of soda has not been fulfilled. The production of iodine from this source has increased but little, and some nitre refineries, which had commenced the utilization of the iodiferous mother-liquors, have again abandoned the attempt.[ii] On the other hand, in tinctorial industry attempts have been made to dispense with the use of iodine. Although the attempt to employ bromine in place of iodine (see "Bromine") has failed,

[i] According to a letter from Mr. E. C. C. Stanford, of Glasgow, to Prof. A. W. Hofmann, a ton of chloride of potassium in 1863 cost £21 13s.; in the ten following years on an average £15 15s.; and is now worth only £7 10s. The price of iodine has risen in a corresponding degree; in 1863 an ounce of iodine cost 4½d.; on the average of the following ten years 7d.; whilst it is now worth 1s 3d. per ounce.

[ii] According to private communications from M. E. Schering the production of iodine from the mother-liquors of soda saltpetre is again on the increase. A Peruvian nitre refinery, which separates the iodine as cuprous iodide by means of bisulphite of soda and sulphate of copper, produced, in 1873, 15,000 kilos. cuprous iodide, and is about to increase its production to 50,000 kilos., corresponding to 30,000 kilos. of iodine.

other methods have recently been discovered for producing the most magnificent violet, blue, and green tar colors without the aid of iodine. Nevertheless the price has not been essentially reduced since the methods for preparing the dyes without iodine have not by any means been adopted in all establishments.

In addition to the tinctorial arts iodine is employed in scientific chemistry, where its importance is incalculable, and also in photography and in medicine.

As regards recently discovered sources of iodine we have already mentioned the mother-liquor of Chilian nitre. No others of importance have been discovered. Leuchs[i] indeed points out that the flue dust of blast-furnaces contains compounds of iodine along with other soluble salts. Thus from the dust of the Rosenberg furnace, near Sulzberg, he obtained 0·034 per 1000; from the Komoran furnace, near Herzowitz, 0·042; and from that at Kreutzthale 0·146, and calculated that 35½ lbs. iodine could be annually prepared at the first-mentioned furnace. But even in the improbable event that the iodine thus occurring could be extracted at a remunerative cost the total production would still be quite insignificant.

As for the total production of iodine there exist few numerical statements from which it can be ascertained. By far the greatest quantity is obtained in England and France. In the year 1871 the quantity produced in Great Britain reached 114,799 lbs., 9-10ths of which came from Glasgow. One of the works there (W. Paterson) in the year 1867 alone produced 112,000 lbs.[ii] In France the production in 1867 was 55,600 kilos.; therefore rather less than in England.

In 1868, 40 kilos. were daily prepared at Tarapaca from Chilian nitre (Balard) corresponding to a yearly production of 290 to 300 cwts. This quantity, however, must be considerably reduced if we remember that Sticht[iii] found only 50 per cent. of real iodine in a Chilian sample.

The method of extracting iodine is essentially unchanged notwithstanding many proposed improvements.

In the Report of the London Exhibition of 1862, A. W. Hofmann describes the process of Stanford which was then taken up with great

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[i] Leuchs, *Deutsche Industrie Zeit.*, 1868, 408. *Wagner Jahresber.*, 1868, 15.

[ii] *Deutsche Indust. Zeit.*, 1867, 8.

[iii] Sticht, *Wagner Jahresber.*, 1869, 221.

zeal, and for which a medal was awarded by the jury. Its principle is the preliminary distillation of the seaweed, and the utilization both of the volatile products and of the residual charcoal with its mineral constituents. According to this process 20,000 cwts. of seaweed yielded 12,860 litres of empyreumatic oil, 31,000 cubic metres of illuminating gas, and 26 cwts. of iodine, besides other less important products.[i] In spite, however, of the favorable expectations which were entertained by experts, this process has evidently failed in practice.[ii] The rock on which the invention has been wrecked is the troublesome and costly carriage of the seaweeds, since a great weight of water must be conveyed along with a comparatively small quantity of solid matter. Moride[iii] has indeed proposed to improve this method. He proposed to dry the weeds in portable furnaces where they are obtained, but nothing further has been heard of the distillation of seaweed and the production of iodine from the residual charcoal.

The method of extracting iodine from the mother-liquors of kelp is still the same well-known process, over which it is needless to waste a word. New methods have been proposed, but have led to no alterations in practice. We may mention the method invented by Lauroy.[iv] He saturates the mother-liquors of Varec with hydrochloric acid, removes the precipitate thus produced, and passes nitrous and hyponitrous acid into the clear liquid. Iodine is thus precipitated, whilst the bromides, simultaneously present, are not decomposed.

The process of extracting iodine from the mother-liquors of Chili nitre, which was at first introduced by Thiercelin in the works of the Société Nitrière, at Tarapaca, and by which, as has been already stated, 40 kilos. of iodine were obtained there daily, is in brief as follows:—The iodic acid present in the mother-liquors is reduced by an exactly sufficient amount of sulphurous acid. The iodine thus precipitated is placed upon a sand filter in a large stoneware vessel with a perforated bottom, which allows the greater part of the saline liquid saturating the iodine to drain away. It is then transferred by means of stoneware spoons into a trough of gypsum with thick sides, which quickly absorbs the rest of the liquid. The crude iodine thus obtained is either offered for sale in this state or submitted to subli-

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[i] *Wagner Jahresber.*, 1864, 186 (from *Journ. de Chim. Medic.*).

[ii] See note at the end of this article.

[iii] Moride, *Comptes Rendus*, lxii, 1002. *Moniteur Scient.*, 1866, 445.

[iv] Lauroy, *Monit. Scient.*, 1868, 1042.

mation. Thiercelin subsequently employed for the precipitation of the iodine nitrous acid, which he obtained by the ignition of a mixture of 5 parts soda-saltpetre, and 1 part charcoal (Duhamel's process for the manufacture of soda).

G. Langbein reports that he has introduced another process in the works of the firm Gildemeister & Co., as the process of Thiercelin disregards the iodine existing as sodium iodide along with the iodic acid. This does not, however, apply to the more recent method of Thiercelin, since hydriodic acid is very readily decomposed by nitrous acid.

The compounds of iodine find little application in manufactures, and are therefore merely produced on a small scale. Proposals for improved methods of preparation are therefore of limited interest and require but a very brief notice.

For the preparation of the iodides of potassium, calcium, and lithium, Liebig[i] proposes to form a solution of phosphoric and hydriodic acids by the reaction of amorphous phosphorus, iodine, and water, and to saturate the acid liquid with caustic baryta. Phosphate of baryta is precipitated and iodide of barium remains in solution, from which (Pettenkofer) any desired iodide may be obtained by precipitation by means of a sulphate. In preparing calcic iodide the acid may be neutralized with milk of lime.

Rud. Wagner[ii] proposes to form the iodides by decomposing sulphides with iodine. For this purpose the sulphite of barium is particularly adapted, which is diffused in water and treated with iodine, yielding sulphate of baryta, marketable as *blanc fixe* and iodide of barium. But the process already in use of reducing sulphate of barium and decomposing the sulphide thus obtained with iodine is evidently simpler.

Fluorine.—Fluorine, which it was hoped would, in its compounds, prove capable of important industrial applications, has in no manner fulfilled the expectations entertained. Many attempts made with this view down to the year 1867 have proved fruitless. Amongst such we may remember the proposal of Weldon[iii] to prepare soda by means of hydrofluoric acid. A solution of sulphate of soda was decomposed by means of hyrofluoric acid, obtained either by heating a

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[i] Liebig, *Ann. Chem. Phar.*, cxxi, 222. *Wagner Jahresber.*, 1862, 257.

[ii] Wagner, Bayer, Kunst, &c., *Gewerbbl.*, 1862, 235. *Wagner Jahresber.*, 1862, 261.

[iii] Weldon, *Dingl. Pol. Journ.*, clxxxii, 228.

mixture of magnesium fluoride and sulphuric acid, or by decomposing sodium fluoride with superheated steam. The sulphate of soda was thus to be resolved into bisulphate, which remains in solution and natrium fluoride, which separates out. This latter salt is either converted into hydrofluoric acid and hydrate of soda by means of superheated steam, or converted into hydrate of soda and magnesium fluoride by the addition of magnesia. The magnesia necessary for this purpose is obtained by heating common salt with Epsom salt ($MgSO_4+H_2O$), forming magnesia, hydrochloric acid, and sulphate of soda, which latter, as above mentioned, serves for the preparation of the sulphate of soda. The magnesium fluoride formed by decomposing the sodium fluoride with magnesia serves for the preparation of hydrofluoric acid, being heated along with the acid sulphate of soda, obtained in the first operation, and thus converted into sulphates of magnesia and soda and hydrofluoric acid, the latter being again applicable for the decomposition of sulphate of soda. Thus all the materials required for the manufacture of soda are regenerated, and merely the common salt and the fuel are consumed. According to the inventor the cost of plant, fuel, etc., is smaller than in LeBlanc's process. As a shorter process Weldon suggests to convert common salt at a red heat into sulphate of soda and hydrochloric acid by means of bisulphate of soda. The sulphate of soda is then dissolved in water, and split up into sodium fluoride and bisulphate of soda by means of hydrofluoric acid, and from the sodium fluoride the hydrofluoric acid is recovered by treatment with superheated steam, hydrate of soda being the final product of this series of reactions. Notwithstanding the alleged remunerative nature of these processes neither of them has found its way into practice.

(To be continued.)

Note relative to the production of iodine by distillation of seaweed, referred to on page 70.—Mr. E. C. C. Stanford, the inventor of this process, writes to the editor of the *Chemical News* (Dec. 1st, 1876):

"I beg to state that ever since 1863 the process has been worked, with great success, in the Island of Tyree, and other parts of the West Highlands. The produce of iodine in that island has been increased tenfold * * * The price of iodine which I gave Dr. Hofmann, and is quoted by him on page 68, was (at the time of writing) 1s. 3d. per ounce; it is now only 5¾d. per ounce."

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. CIII. FEBRUARY, 1877. No. 2.

EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

The Scope of Governmental Interference for the Prevention of Accidents.—Two catastrophies of exceedingly deplorable character have recently occurred, which bring forcibly before the public the necessity of some preventive measures. The burning of a theatre in Brooklyn, on the night of the 5th of December last, has cost over 300 lives; and the falling of a bridge at Ashtabula, Ohio, on the line of the Lake Shore Railroad, on the night of the 29th of the same month, has involved the lives of over 160 persons in the disaster. The question of what is to be done to prevent similar catastrophies, is now a proper one for consideration.

It can be asserted without exaggeration, and upon grounds which will bear examination and be supported by abundant proof, that there are many theatres in any of our cities, and many bridges on some of our railroads, as liable to an accident, possibly more liable, than those by which so deplorable results have ensued. The theatre in Brooklyn was not an exceptionally dangerous structure—a skilled

architect in this class of building was entrusted with its erection—and no reckless or unusual disregard of precautions existed, no assumption of risk was made to save cost in construction. Subsequent examination of the theatres of Philadelphia disclosed that much less adequate means for escape of an audience have been provided in several theatres which have been constructed and used for years. The chances that a fire should occur at all in any theatre, *any year*, is not, perhaps, 1 in 200 or 300, whence the chance *any day* is but 1 in 75,000 or 110,000; while the chance that a fire will occur when a performance is going on, is not over one-half these ratios, and 1 to 150,000 to 200,000 is, perhaps, a fair estimate of the risk of burning during the time of a performance on any given day. Even this great ratio is increased when the individual chance of escaping from the fire is taken into the account, so that the risk of life to any man, woman or child, in any theatre, any night, is not 1 in 1,000,000. The risk of loss of property by owners each year is, as has been taken, 1 in 200 or 1 in 300, and the insurance is cheerfully paid, after which no feeling of risk remains with the owner. Even if the construction is admitted to be dangerous, the ratio of extra danger is met by an owner in enhanced premiums, at much less expense than the cost of alteration to remove danger, while the underwriter is happy in the increased profit which the rate of premium affords. These small risks are accepted by the entire community. When, in the fulness of time, the disaster at Brooklyn, or elsewhere, occurs, the immediate shock will affect the pleasure-seeker, and attendance will fall away from places of amusement, a spasmodic official inquiry will be instituted, a number of moral communications be offered to the newspapers, and a few which are entirely impersonal, as regards any possible advertising patrons, will be published; but the seven days' wonder will pass away, and the old rule of "taking the chances," will be re-established with greater strength, as the next catastrophe *may* not not be so dreadful as the last.

The same considerations attach to the railway accident. Statistics exhibit that it is almost safer to live in a railway carriage than in one's house. Many thousand trains, running many thousand miles, and transporting many thousand passengers, will have passed over railways without one accident involving loss of life to a passenger, and each passenger takes the risk for himself with little fear or

scruple. Cheap construction, cheap management, large dividends, are substantial evidences of skill, ability, and enterprise in the direction of a railroad. The directing manager takes the risk. Not every unsafe bridge falls; not every bridge that falls involves *considerable* loss of life or property. Powder magazines do not frequently blow up, and the keepers of such magazines sleep as soundly at their appointed hours of rest as other people. This proposition that not every unsafe bridge falls, is readily admitted by all practical engineers. There are unquestionably hundreds of bridges on lines of running railroads as unsafe in theory as that at Ashtabula was from its beginning. Constructions vary in diverse ways in almost infinite combinations, and strains or stresses are brought into action by these variations in very unexpected ways. Imperfections of material are a necessary accompaniment to material itself, and tests which might be instituted to find out flaws or defects not unfrequently impair the strength of the tested piece to, or beyond, the limit of safety. Both theoretical knowledge and sound judgment, therefore, are demanded for bridge construction or inspection, but neither knowledge nor judgment can assert that an unsafe bridge will certainly fail, if such a bridge has only a degree of unsafety. For the benefit of non-professional readers it may be permitted to enlarge on this point, by saying that average wrought iron will sustain a pulling strain of 50,000 to 60,000 pounds to each square inch of section under strain, but it will begin to yield—extend permanently—at about 18,000 to 20,000 pounds per square inch. When this extension commences the iron becomes weaker for bearing a shock or blow, and repeated extensions finally break the piece. It follows that the limit of absolute strength for railroad bridge use is 18,000 to 20,000 pounds per square inch. The same figures nearly, apply to compressive strength of wrought iron, only the effect of want of homogeneity of iron in any pillar is far more disastrous than such effect in a rod under tension, as the yielding of the softer parts may—in fact do—tend to *cripple* a pillar and bring into action some severe cross-strains on the unyielding portions. Whence the strength of a strut or pillar depends on the ratio of its sectional dimensions to its length by known laws, founded on experiments on pillars of different proportions. Finally, taking all the effects of maximum loads on a railroad bridge, it is good practice to provide such sections of wrought iron as will give about 10,000 pounds tensional strain on long ties, and 8000

pounds of compressive strain on columns of 20 diameters in length. At the same time the load on a bridge, of long span, is taken at a maximum of 2000 to 3000 pounds per running foot of track. It will be seen that these figures are from one-fifth to one-sixth what iron *might* bear, and that any bridge may stand for years, although weaker than good practice has dictated.

It has been the purpose of these remarks to show that there exists no inducement on the part of the owners of theatres and the managers of railroads to *prevent* the recurrence of these accidents in any other way than what they have already done. As individuals, they may feel "very bad about it," when a disaster occurs; they may even go so far as the unfortunate Mr. Collins, the engineer of the Lake Shore Road, who has found his responsibility unbearable; while the evidence so far given makes it certain that a condemnation of the bridge on his part would have merely dismissed him from his post as it did a previous engineer. But all this affords no protection to the public, and Governmental interference becomes, therefore, the only way to secure the desired end.

With regard to the buildings, it is probable that local or preferably State legislation should be taken, and a rigid inspection, with power to enforce results, established. As to the railroads, there is a special constitutional provision, which gives Congress power over them, and it should now be exerted to the utmost. The happy results which have come from the inspection of steamboats, where precisely the same influence had *perpetuated* a long series of disasters, indicate what can be anticipated from a Board of Inspection of Railways of the United States with similar authority.

The passage of law obliging owners or directors to have inspections made previous to occupancy or use, and at stated intervals afterwards, by their own officers or employees, however competent as architects or engineers they might be, would fail to meet the exigencies, as recent accidents show such inspections would have a controlling bias in favor of the employers' interest as a matter of economy or profit. It is between the public as guests or travelers, and the owners and directors as hosts or common carriers, that the question lies. The *judges* should be not only competent, but amenable to none but the public authorities. The enforcement of proper laws might work some hardship at first, in trouble and immediate outlay, but in the end it would prove profitable to theatres and railroads.

Franklin Institute.

Hall of the Institute, Jan. 17th, 1877.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were 150 members and 10 visitors present.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting 40 persons were elected members of the Institute, and the following donations were made to the library:

Report of the permanent committee of the first international congress at Vienna, meeting at London, 1876. From the meteorological committee.

Discussions on technical education by the American societies of civil and mining engineering. Easton, Pa., 1876. From the Am. Soc. Mining Eng's.

Verhandlungen des naturhshistorisch-medecinischen Vereins zu Heidelberg. New ser. Vol. I, Pt. 4. From the union.

Catalogue of the collective exposition at the Centennial exhibition in 1876, at Philad'a, of the Netherlands booksellers' association. Amsterdam, 1876. From Dr. Geo. J. Ziegler, Philad'a.

Report of the board of health of the city and port of Philad'a to the Mayor, for the year 1875. From Geo. E. Chambers, registrar of the board.

Memoires of the imperial Russian technical society and collection of patents issued in the department of commerce and manufacture. 1876. 4 vols. From the society.

Secular change of magnetic declination in the United States and other parts of North America, 1874. From the U. S. coast survey.

Report on the North Sea canal of Holland, and on the improvement of navigation from Rotterdam to the sea.

(To be continued in next number.)

The President presented the following Annual Report of the Board of Managers, which was adopted:

Report of the Board of Managers to the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts, for the year 1876.

Your Board of Managers beg respectfully to submit the following Report:

Members.—During the year 1876 there were elected one hundred and thirty-two members—and thirty-one resignations.

Treasurer's Report.—The report of the Treasurer herewith submitted as extracted from the minutes of the Board, presents the following exhibit:

Balance on hand Jan. 1st, 1876, . . .	$2,218.65
Receipts during the year from all sources, . .	17,622.71
Total, ...	$19,841.36
Expenditures and investments during the year,	18,849.35
Leaving a balance on hand, Dec. 31, 1876, of	$992.01

Premiums and Medals.—During the past year the following medals and premiums were awarded:

Elliott Cresson gold medal to W. G. A. Bonwill, for his electro-magnetic mallet for dental purposes.

Scott Legacy premium and medal to C. Tyson, for his machine for uniting the soles to boots and shoes; to Morris L. Orum, for his flexible mandril for bending metal pipes, and to Chambers, Bros. & Co. for their brick-making machine.

The Journal of the Institute.—The Journal, which is under the management of the editor and the committee on publication, has not been self-sustaining for the past year.

Drawing School.—The Board are able to report the night drawing school as having been reasonably satisfactory in its operations; although they have to state that in consequence of the general depression in business, its numbers during the year have been somewhat diminished. The attendance at the school in the Spring was 103, and in the Fall was 81.

Lectures.—The lectures given during the earlier part of the year, from Jan. 4th, to March 21st, were: by C. B. Dudley, on Artificial Ice; by Robert Briggs, on Steam Boilers; by Prof. E. D. Cope, on Paleontology; by Joseph Zentmayer, on Lenses; by Prof. P. E. Chase, on Physics; by Prof. Persifor Frazer, Jr., on Geology; by M. B. Snyder, on Astronomical Spectroscopy; by Prof. L. M. Haupt, on Tunneling.

The attendance on these lectures was generally good and on some of them the lecture room was crowded.

The lectures arranged for this Winter were of two classes, the one being of the usual popular scientific character, admitting of extensive

experimental illustration, and the other for elementary instruction. The subjects chosen for the latter series were the first principles of dynamics, and elementary chemistry.

Such series of elementary lectures were in former years given each season, and the privilege of attendance on them was considered one of the most valuable rights of membership, and they were undertaken the present season with the hope of renewing the interest formerly felt for them, and of extending this kind of instruction to the younger members, and to those who may hereafter become such.

The lectures given from Nov. 14th to the end of the year were six on Light, brilliantly illustrated, by Prof. E. J. Houston, and five on the first principles of Dynamics, by Prof. W. D Marks. The attendance on these lectures has been larger than usual, and especially those on Light, when the Hall has been nightly crowded.

Prof. Houston also gave, gratuitously, in Christmas week, one lecture on "Familiar Science" to the children and wards of members, which was highly appreciated.

Phonography.—Courses of instruction in Phonography have been given in the Hall of the Institute since November last, by Mr. D. S. Holman, Actuary. These courses, introduced for the first time systematically in the Institute, have proved very popular and attractive, and promise to become a valuable addition to the useful work of the Institute. So great has been the interest awakened in this variety of shorthand, by the efforts of Mr. Holman, that the number already registered in his classes reaches 131, and is steadily increasing.

Monthly Meetings of the Institute.—The attendance at the monthly meetings of members and strangers has been well maintained during the year, and interesting communications and noteworthy inventions and novelties have been presented and discussed on those occasions.

Library.—A statement of the condition of the library will be presented by the Committee on the Library.

The reports of the Committees on Models and on Science and the Arts will be read at this meeting, and will show what has been done in that connection.

Centennial Exhibition.—Believing that the objects of the Institute would be advanced by extending hospitalities to strangers visiting the Exhibition, the Board of Managers quite early secured a room in Machinery Hall for an office and reception room, where strangers

would be welcomed and could confer with some officers of the Institute on matters of mutual interest.

A Committee of Reception was appointed to take charge of the room and receive and give information to visitors. The report of this committee, submitted to the Institute at the last meeting, shows its operations.[i] To make the reception room the more useful to visitors, the Board directed the Secretary to ask publishers of desirable journals to donate for that use the numbers of their publications from May 1st to November 1st, which was very generously responded to by leading scientific and technical journals of this country and Europe.

The Institute also extended the free use of its library and reading room to all members of kindred societies at home and abroad, and this privilege was largely availed of by both private and official visitors.

Exhibitions.—It appearing to the Board that the holding of annual exhibitions by the Institute was not advisable, and that one in every three or four years would be often enough, and anticipating the great benefit to be derived from such an arrangement, the Committee on Exhibitions was authorized to correspond with other societies of like character in the Atlantic cities with the view to quadrennial exhibitions in Boston, New York, Philadelphia and Baltimore. This resulted in a convention[ii] of the representatives of the Mass. Charitable Mechanics' Ass'n, of Boston; the Franklin Institute, and the Maryland Institute of Baltimore, and finally in the adoption by these societies of an agreement to hold exhibitions triennially (or quadrennially if the American Institute of New York will join in the arrangement) in their respective cities.

As one of the great difficulties hitherto encountered by the Institute in holding its exhibitions has been the procuring of a suitable building, and as the Machinery Hall of the Centennial Exhibition was built and is owned by this city, the Board of Managers petitioned Councils[iii] to maintain and preserve that building for this and other public purposes, which resulted in the adoption of the following ordinance, approved by the Mayor Dec. 12th, 1876:

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[i] The proceedings of this convention will be found published in Vol. cii, page 291, JOURNAL OF THE FRANKLIN INSTITUTE.

[ii] See Vol. cii, page 293, of the JOURNAL.

[iii] See Vol. ciii, page 8, of the JOURNAL.

"An ordinance for the retention, use, and management of Machinery Hall, in Fairmount Park.

"WHEREAS, The building recently used by the International Exposition, in Fairmount Park, and known as Machinery Hall, was built by and paid for with the money of the City of Philadelphia; and whereas, members of the Franklin Institute and other citizens have requested Councils that the building may remain, to be made available for useful purposes; and whereas, the Park Commission are willing that the said building may continue in its present location so long as the city desires it; therefore,

"Section 1. The Select and Common Councils of the City of Philadelphia do ordain:

"That Machinery Hall, within Fairmount Park, shall be permitted to remain until otherwise ordered by Councils, and that the same be placed in charge of the Park Commission, for the purposes of public exhibitions by the Franklin Institute, and such other purposes and objects, and under such regulations as the said Commissioners may deem expedient; the Councils hereby reserving to the city the exclusive ownership of the building, and the right to reclaim and remove it whenever they choose so to do."

With a view to aid in the illustration of certain lectures, and to enable exhibitors to show at the monthly meetings the operation of their machines or models, the curators have been authorized, and have purchased a steam engine of six-horse power.

In conclusion, the Board of Managers feel that they can again cordially congratulate the Institute upon its increased prosperity, and its promising prospects in the future.

All of which is respectfully submitted.

By order of the Board. R. E. ROGERS, *President.*

The Committees on Library, Models, and Science and the Arts, presented their reports as follows, which were adopted:

The Committee on Library would respectfully report that they have held monthly meetings with the usual good attendance. The catalogue of the books, which was in progress at the beginning of the year, was completed and printed in August, and makes an 8vo volume of 452 pages, and is a full and complete reference to all the books in the Library. The cost of this work was quite large, but in view of the increased usefulness of the Library, your Committee consider the outlay fully warranted.

The Catalogue, bound in cloth, is now for sale by the Actuary, at $2.00 per copy.

The following additions have been made to the Library:

Bound volumes donated, including 420 vols. formerly deposited by A. Seybert,	599
Bound volumes purchased,	150
Number of volumes, Exchanges, bound,	266
" " British Patents, bound,	286
" " other books, bound,	147
Total number of bound vols. added to the Library,	1448
Number of Pamphlets donated to the Library,	408
There are now in the Library bound vols. of British Patents,	2717
Indices to same,	66
Abridgments,	52
American Patents,	177
Total number of bound vols. in Library,	11,966

There is also a large number of unbound vols., but the number not ascertained.

Our set of British Patent Office publications, consisting of Patent specifications, abridgments and indices, is now full, with now and then a rare exception, and we are receiving the current numbers quite regularly, as also the Commissioner of Patents Journal, weekly.

The set of American Patents is complete from 1841 to date, so far as published.

There have been expended during the year, for the purchase of new books,	$1260 84
There have been expended during the year, for binding books,	453 70
Making a total, for the improvement of Library, of	$1714 54
And there still remains a balance from the appropriation of $5000 for the improvement of the Library, made Jan. 13th, 1875, of	1403 54
There were expended from the subscription fund, for binding British Patents,	115 25
And there still remains a balance of	71 15

As was anticipated at the beginning of the year, the attendance at the Library, and its use by members, is much greater than before, and is still increasing.

By order of the Committee. CHAS. BULLOCK, *Chairman.*

The Committee on Models respectfully report that very little has been done to the models during the year, for want of space in which to properly display them.

The Board of Managers at its meeting in December passed a resolution requesting the committee to report to the Board the extent and condition of the collection of models belonging to the Institute.

As there was no list of the models it was decided to take the measure of the larger and more important models and relics distributed about the room and to measure the shelves now occupied by the smaller ones.

One hundred and eighty models were measured and numbered, and entered in a book, and it is proposed to continue this at some future time to cover the whole collection.

The actual shelf room necessary to hold the models, when placed in contact with each other, is thus estimated at about 1000 sq. feet.

As models should have not less than twice their dimensions on the shelf, to display them properly, our collection will require 2000 sq. feet of shelf room.

Of all the models in the collection about one-third requires more or less repairs, and all need a thorough cleaning. There are a number of models of considerable historic interest in connection with the Institute, and a large number representing inventions passed upon by the Committee on Science and the Arts, and its predecessor, the Committee on Inventions; and a smaller portion are models remaining from early exhibitions; in fact the collection as a whole derives its greatest interest because of its connection with the work of the Institute. There are, however, many exceptions in which the models are in themselves of value, as representing progress in the arts, and for educational purposes.

While recognizing the advantages to be derived from the collection, if properly displayed, the committee, in view of the financial condition of the Institute, have not felt warranted in recommending the large appropriation necessary to accomplish it.

By order of the Committee.

C. Chabot, *Chairman.*

The Committee on Science and the Arts would respectfully report that there has been an unusual amount of interest manifested by the members during the year, as well as a larger number of applications for reports on inventions.

The average attendance during the year at twelve stated and one adjourned meetings, was $30\frac{8}{13}$ persons, the highest number being 40 in May, and the lowest, 21 in July.

At the beginning of the year, there were pending applications for reports,	18
Number of applications during the year,	61
	79
Number of reports adopted during the year,	29
" " applications withdrawn,	3
" " " dismissed,	9
" " " pending Dec. 31st,	38
	79

The medals recommended, and which were afterward awarded by the Board of Managers, were two, as follows:

The Scott Legacy premium and medal to Morris L. Orum, for his flexible mandril for bending metal pipes, and the Scott Legacy premium and medal to Chambers, Bros. & Co., for their brick-making machine.

The amount of money expended, during the year, for notices, is $46.40.

By order of the Committee.

COLEMAN SELLERS, *Chairman.*

On motion the order of business was suspended and Mr. Wm. Welsh offered the following, which was seconded by Mr. J. W. Nystrom, and unanimously adopted:

WHEREAS, It is alleged and generally believed that the education of children in our public schools and in private seminaries, does not dignify labor or furnish the pupils with any special preparation for mechanical and other useful arts, and

WHEREAS, The Franklin Institute of the State of Pennsylvania was founded to promote and encourage manufactures and mechanical and useful arts by all such measures as its members may judge expedient; therefore,

Resolved, That a Committee of seven members of this Institute be appointed, with power to confer with Boards of Education, Directors and Teachers of Schools, and with others interested in the special training of youth of both sexes, for industrial pursuits; reporting to this Institute the result of their conferences, and the extent of the alleged defect in education, with such remedial measures as the Committee may deem practicable.

Mr. Welsh moved that the President be a member of the Committee, and that he appoint the remainder at his leisure, which was carried.

The Committee, as appointed by the President, is constituted as follows:

Wm. Welsh, *Chairman*, Dr. R. E. Rogers, Jas. S. Whitney, Wm. A. Ingham, Jos. M. Wilson, Enoch Lewis, F. O. Horstmann, and J. B. Knight, *Secretary*.

The President called Vice-President J. E. Mitchell to the chair.

The Tellers presented their Report of the Annual Election held this day, which was accepted, and in accordance therewith the chair declared the following members elected:

President, Robert E. Rogers, M. D.
Vice-President, Henry G. Morris.
Secretary, J. B. Knight.
Treasurer. Fred. Fraley.
Managers to serve three years, Prof. E. J. Houston, Enoch Lewis, C. H. Banes, Wm. Helme, Sam'l Sartain, Chas. Bullock, John Sartain, C. Chabot.
Auditor, Wm. Biddle.
Representative to the Penna. Museum and School of Industrial Art, J. B. Knight.

The Secretary presented his Report, which embraced a number of attachments for improving the draft of chimneys, and the heating and ventilation of buildings, designed by Mr. Wm. Welsh[i]; J. A. Lock's Paper Pulley-cover; Marsland's Water Meter; Specimens of tissue paper and cotton cloth, rendered incombustible by being saturated in Tungstate of Soda; and a cylindrical Holtz Electric Machine, made of Paraffined paper, designed and built by Prof. Elihu Thomson.[ii]

Mr. J. B. Knight, representative of the Institute in the Board of Trustees of the Penn'a Museum and School of Industrial Art, presented the following report:

Pennsylvania Museum and School of Industrial Art.—At the meeting of the Institute in June last, I made a Report[iii] covering the principal features in the progress of the association up to that time, and would now present the following:

It having been the original intention in organizing the museum, to take advantage of the opportunities offered by the International Exhibition, and the subscriptions having reached an amount which

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i ii Descriptions of the Ventilating apparatus of Mr. Welsh, and of the Holtz Machine of Prof. Thomson, are necessarily deferred to the next number of the Journal.

iii See Journal for August, 1876, page 79.

warranted the expenditure, the Board appointed a Committee on Selection, and clothed it with authority to purchase at the exhibition, suitable objects for the museum collection to the value of $25,000. With this, and under special appropriations, they have made very judicious purchases to more than $33,000. The promises of assistance and donations from foreign commissions, referred to in my former report, have been fully realized, and by them many valuable additions have been donated to the collection.

The Board of Trustees, in its Annual Report, acknowledge the great interest in the museum manifested by persons outside of Philadelphia, and especially to that of Mr. P. Cunliffe Owen, of the South Kensington Museum, London, who, among other important acts, has secured permission from his government to have reproduced for our Museum, a number of pieces of royal plate of great historical and artistic value, now in the Tower of London.

The Board was also fortunate in having secured Dr. Christopher Dresser to deliver under its auspices, three lectures on Industrial Art Education, which were of great value, both from their intrinsic merit and the marked influence they had in directing attention to the importance of the work undertaken by the Museum.

The Governor of the Commonwealth, in his recent message to the Legislature, again pointed to the necessity of Industrial Art Education, and refers to the important part to be borne by the Museum, and asks the Legislature to "seriously consider whether * * * * the "State ought not to extend a hand to place upon a firm foundation "a work of so much public utility."

The time of occupying Memorial Hall is necessarily somewhat delayed, in order to make the required preparations for receiving and arranging the objects; but it is expected that the Museum will be opened to the public during the coming Spring.

Meanwhile, with a view of bringing the Museum more prominently before the public, the Board of Trustees authorized the holding of a temporary exhibition, consisting of such objects from its own collection as are available, supplemented by objects loaned from private collections. Arrangements were made with the Academy of Fine Arts for the use of the south tier of galleries in its building, and the exhibition was opened on Jan. 16th, and will continue open until March 31st.

It will be remembered that one of the principle means to be employed by the organization in its work of improving the character of

our manufactures, is the establishment of Schools of Art, as applied to the industries, where drawing and designing, in their more advanced stage, shall be thoroughly taught. A widespread interest is manifested by our citizens, and there has been much inquiry regarding the opening of the schools, and which, with other evidence of a strong demand for such instruction as shall be available in making a livelihood, shows that the time is ripe for the establishment of the Museum's schools. The Board of Trustees has been unable as yet to complete the details necessary to put them in operation, but timely notice will be given of the opening.

The members of the museum, realizing the great public importance of giving a more practical direction to the instruction in our public schools, and how much the work of establishing art schools will be advanced thereby, adopted a Report from its Committee on Education on that subject at the Annual Meeting of the Corporation, held Jan. 8th, 1877, in which reference is made to "the position of Phil-"adelphia as a manufacturing city, and to the fact that the large "majority of the children being educated at the public expense, are "the sons and daughters of those engaged in the multifarious indus-"tries of the city, and who in their turn will become mechanics and "artisans. * * * * Heretofore, it is well known that the "instruction in our schools, most excellent of its kind, has been almost "exclusively of a literary character, and * * * * would, no "doubt, be of the greatest value to a resident of a city devoted to "letters or to mercantile pursuits, but in such a city as our own, "where the whirl of the loom, the stroke of the hammer, and the "countless sounds of a people actively engaged in industries of the "most practical character, daily strike upon the ear, your Committee "are of the opinion that the present plan of instructing the young "of Philadelphia is by no means complete, and that here especially "the study of drawing should be enforced as an essential branch of "education.

"The establishment of a complete system of Industrial Art Edu-"cation by this Corporation, will supply opportunities for the instruc-"tion and training of teachers, which will obviate the necessity of the "very large expenditure involved in the formation and support of a "normal Art School."

Owing to the very depressed condition of business, the difficulties in obtaining subscriptions to any enterprise of this nature, have been very great, but under the circumstances the success of the museum in

this regard, is considered quite encouraging, the amount secured up to Dec. 31st, 1876, being $70,000, and the number of persons elected members is one hundred and fifty.

It is important, however, to keep in mind the fact that the Museum is supported entirely by subscription, and I would urge upon the members of the Institute the importance of increasing the membership and the subscriptions to its fund, thus enabling it to assist in carrying out the principle upon which the Franklin Institute is founded—the promotion of the mechanic arts.

Members and subscribers have the following privileges:

Life Members paying one hundred dollars, and Subscribers to the amount of two hundred dollars, are entitled to one season ticket annually, or in lieu thereof, to twenty-four single tickets of admission to the Museum and its collections for each one hundred dollars subscribed.

Annual Members paying ten dollars yearly, are entitled to one season ticket and sixteen single admission tickets, or in lieu thereof, to forty single admission tickets.

As showing the intimate connection between the Museum and the Institute, I would call your attention to the fact that out of thirty-two Trustees composing the Board, thirteen are Members of the Institute, and five of these are Members of the Board of Managers of the Institute, and one of these, Mr. Coleman Sellers, is President of the Museum.

J. B. Knight,

Trustee in behalf of the Franklin Inst.

Mr. F. M. M. Beall offered the following:

Whereas, A bill is at present pending before Congress, asking aid for carrying into execution the scheme of Capt. H. W. Howgate, of the Signal Service, for reaching and exploring the region about the north pole on the plan of colonization,

Resolved, That the Franklin Institute approve of this plan, not only for its economy, but for its apparent practicability, and believe it to be the most feasible plan yet offered.

On motion of Mr. Close the consideration of the subject was postponed to the next meeting.

On motion, the meeting adjourned.

J. B. Knight, *Secretary.*

Civil and Mechanical Engineering.

THE ESCAPEMENT OF THE "HIPP" CHRONOGRAPH, AND THE MEASUREMENT OF SMALL INTERVALS OF TIME BY ITS MEANS.

By ROBERT BRIGGS, C. E.

[Abstract from remarks at the meeting of the Franklin Institute, Nov., 1876.]

The attainment of some degree of accuracy in the measurement of intervals of time has been, in every age, one of the tasks which has been accepted by all conditions of humanity, as a desirable and necessary labor, to be followed to a certain result. As mankind emerged from barbarism, each race came to appreciate the value of defined periods of time, and adopted those most obvious; and sought carefully for means of comparing and dividing them. That time could only be measured by the recurrence of some movement in nature, was the immediate deduction; the period of a day and a night, with the recurring order of sunrise and sunset, light and darkness, of the demand of human nature for sleep or food, formed an obvious interval, or unit of time. Other natural phenomena of movement follow in the sequence of days. The moon marks out a certain number of days, at the expiration of which the new or full moon will occur, and in narrating or anticipating any events of life, the longer unit of the month became the measure of time for the semi-barbarous races. But the recurrence of the seasons was quickly discovered to be a more important event in human economy, than that of the months, and some of the earliest recorded efforts of civilization were directed to the determination of the length of the year, *measured* in months or in days. In about the same latitude as that in which we live, the scientific men of nearly 3000 years since, magi or magicians, came to estimate with much accuracy the number of days, and parts of days, which formed the cycle of the year. Careful observation of the movement of the heavenly bodies showed, that at the end of about 365 days, as they determined it, the phenomena of altitude of

the sun recurred, the positions of constellations with regard to midnight, repeated themselves; and the recurrent interval of a year's length of time was established by the movement of these bodies. The phases of the moon were measured out in days and parts of days by those same magicians, and discovered not to be in even numbers, while the repetition of the moon's movements did not make even number divisions for the year. But these physical intervals were all so well marked, as to have been adopted by communities and nations, and used for prolonged periods as their units in the transactions and in the records of life. The assimilations of these communities, or the establishment of empires, or conquests of nations, the attempt to use all these units at once, and preserve the advantages and the established custom of usage for each, led to many devices for making them intercommensurable with each other, without fractions. The relics of these devices have come to us in the Julian and Gregorian systems for compensation of the fraction of the day in the year's length, and in the arbitrary division of the year into twelve months or moons of irrational value, possessing no exact relationship to the periodicity of the moon's apparent motion around the earth. The week of seven days, which we have as one unit of time, is merely, beyond its theological relations, a notation of sevens for aggregating units into numbers, in the same way that ten is a notation of our decimal system, only that the system of sevens is not carried beyond its first power.

All the measurements of time depend on movements, and when it was thought desirable to use for reckoning or statements, any definite part or fraction of a day, some other movement of uniformity than that of the heavenly bodies, was sought, whose recurrence some number of times in a day, with regularity, would allow the desired division to be valued. It is obvious that this movement of recurrence must be so small, that some number of its repetitions should indicate the length of the desired division or fraction of a day. The day has come to us from a remote antiquity as divided into 24 hours, which are again subdivided into 60 minutes, and yet again, the minutes are subdivided into 60 seconds. Of these divisions, that into 24 hours, seems purely arbitrary, and no reason can be suggested for its derivation; but the notation of 60, in this case a complete notation to the second power, is unquestionably based upon the assumption that, given any unit of measurement in habitual use, the 60th part is so

small that further division is uncalled for. The same assumption is made by us in the United States as to a percentage, or hundredth of anything. The duration of time of a second, however, when considered by itself, is a very considerable period. Perhaps the readiest appreciation can be had by comparison with the time of a pace or step, which is from one and a half to two steps in a second, in ordinary walking. Rates of progress which correspond to from $2\frac{1}{2}$ to $3\frac{1}{3}$ miles in an hour. This exhibition of the length of a second admits of comparison with the movement of the individual, and gives $3\frac{3}{4}$ to 5 feet of lineal dimension as the length of a second. The German measurement of distance is by the hour, which corresponds to three English miles, and represents the distance to be walked in the given time.

These brief remarks in prelude have been made to impress it firmly on the minds of my hearers, that *time* is a condition of movement, and its measurement in all cases depends on the accuracy of some phenomena incident to motion. No division of a unit of time can be made except by establishing some smaller unit. Given one series of recurrences, it is necessary in order to effect a division or measurement of any interval between any successive part of the series, to possess another order of recurrences, smaller than the first.

In effecting this end, every species of recurrent motion has been employed. The water clock, which produced by the constancy of flow of a stream of water a definite number of revolutions of a wheel in a day, was one of the earliest methods of comparative merit and success. Balance wheels and fan wheels were employed as means of production of regular speed; in fact, every species of running motion was availed of to form bases or units of length. Little real progress, however, was made in horology, until the modern revival of science, when, about four hundred years ago, the isochronism of the pendulum, and of the spring combined with a reciprocating balance, was brought into action to regulate the clock and the watch.

The pendulum and the spring have remained the most accurate of measures. The ingenuity of modern science has been expended in perfecting them, until the astronomical clock and the chronometer have become marvelously accurate as standards of uniformity and precision. Day by day the second's pendulum of a clock of the higher order of construction, spaces off its 86,400 steps, all of the same duration, until at the expiration of this immense number of beats but a fraction of a second of gain or loss will have taken place.

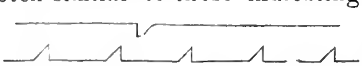
At this point the limit of accuracy attainable by adjustment will have been reached; but by computation even this small error is to be removed. Astronomy has demonstrated that the days vary in length at different seasons of the year, and the amount of such variation has been calculated, so as to establish the length of the *mean day*, which is supposed to be of uniform length. The astronomical time of day can be found by observation of some of the heavenly bodies with great accuracy; by the *equation of time* the mean time can be derived with equal accuracy, and the gain or loss of time by the clock can be determined; and the gain or loss in any twenty-four hours is known as the *rate* of the clock. The uniformity of *rate*, the equality of the variation each day, thus becomes the standard of excellence of the clock, and the adjustments of the pendulum having reached the limit of careful workmanship, the compensation for the error of *rate* remaining, can be effected by dividing up the *rate* amongst the seconds which have passed at any assumed instant.

These steps of seconds, it is thus shown, have become very definite and accurate divisions of the day—they can be accepted as absolutely equal intervals of time—just as years are equal to each other and as mean days are defined parts of equal lengths of a year—but the second is yet indivisible except by guess. The movement of a clock during the day is apparently a uniform one, yet it is composed of escapements of seconds, and the clock actually comes to rest during a part of each second to allow the second to be completed and pass away.

Now the same seeking for precision that divided the day into hours, the hours into minutes, and the minutes into seconds, has sought the division of the second into smaller parts, through the establishment of a movement of uniformity which shall have so short steps *as its units*, that each step of itself shall be imperceptible in the resulting motion. There are many ways of effecting this. A spring or falling weight will put in motion a train of wheels, and the uniformity of speed may be regulated by constant-resistance-friction-fly wheels, or fan wheels operating in air or water, or may be governed by the circular pendulum (or governor of the machinist), and a uniformity of motion of more or less completeness can be thus secured. It is not necessary that the uniform motion for this purpose should be at a definite speed, just so fast each second, but advantage can be taken

of the principle I have before alluded to, when describing the way of getting the *rate* of a clock. Suppose the nearly uniform motion be imparted to a cylinder or riband on which a line is traced; now if any mark or prick or indication is given along this line, at the instant of passage of each second, it will follow that the line can be divided up to indicate the parts of a second with much accuracy.

The real method now employed in astronomical observations is as follows: A train of wheels put in motion and regulated in some way to the requisite uniformity, gives rotation to a barrel covered with paper (or draws a paper riband), on the surface of which a pencil is tracing a line (in the case of a barrel the pencil is made to have a small side traverse or feed, so that the line becomes a continuous screw thread), and each second a mark is made on or near the line by the action of the (seconds) pendulum of the astronomical clock. In point of fact the pencil which makes the line is generally made to give the indication of the length of the second, by having a sudden sidewise movement imparted to it, and the line described on the surface of the barrel, in lieu of being a straight one, is notched or jagged as shown . The connection of the movement of the pencil to the pendulum is thus effected. At some convenient point on the rod of the pendulum, more suitably near or at its lower end, a pin is allowed to project. The rate of motion of the pendulum is, of course, greatest as it passes the perpendicular line, and at this place the pin comes in contact with a lever-key, which it depresses into a mercury cup and establishes the circuit of a battery. An electro-magnet is thus excited and its armature attracted. The pencil which traces the line on the revolving cylinder is, by the construction of the apparatus, arranged to be moved sidewise by the action of the electro-magnet, and the resulting line will become as shown with a notch for each second of time. A similar arrangement of pencil and electro-magnet allows an astronomical observer to record the exact instant of an observation. The second pencil is employed in tracing another line parallel with the *seconds* line, upon the same cylinder or riband, and the astronomer, by touching a key (like the key of a Morse telegraph), produces a notch similar to those indicating *seconds*. The appearance of these



lines and notches is shown on the accompanying sketch, and the relative position of the notches makes it evident in what way the por-

tion of second, from the instant of observation to the whole second, can be measured with great accuracy.

The oldest method of giving uniformity of motion to a train of clock-work was by means of a *fly* or small fan wheel, but beside the difficulty of adjustment, no very close approach to *equality* of movement can be had in the use of the fly, although a fairly uniform motion may be obtained during any one second, or even for several consecutive seconds. In fact before the discovery of the constant motion of the pendulum, which is ascribed to Gallileo, and its application to an escapement, which is ascribed to Huyghens, the *fly* was the usual regulator of the clock. Such a clock required to be *set* from day to day—it must be compared and made to correspond with a sun-dial, or with some other natural indication of exact time at a given moment. The chronograph which I have described is *set* from second to second, by the marking of notches at the end of each interval. Probably most of my hearers have examined the works of the common music box and discovered that its regularity of motion while playing a tune is due to the fly. A very little practice in the use of this method of attaining uniform motion demonstrates its unsatisfactory character. The resistance from the friction of the bearings of the rapidly rotating *fly*, and of the train wheel work which impels it, bears so large a ratio towards that which is derived from the action of the wings of the *fly* in the air, that the variation in the first resistance which constantly occurs in use, is often greater than the regulating power of the latter resistance. By no means the least difficulty in regulation with a *fly*, arises from the change of density of the resisting medium—the air, which, between 30° and 80° Fah. of temperature, and between 28 inches and 30 inches of barometric pressure, will give a greatest variation, of nearly, as four is to five in density, and changes the rate very materially. The *government* of motion by some one of the forms of the rotary pendulum, which of itself may be made isochronous, or in other words to rotate in equal times, whatever the position of the balls, whether they resist gravity more or less modified on a spring, has been frequently attempted, and often with much success. The method is open to two objections, one in principle—that all rotary governors operate by bringing into action or relieving some resistance *after* the governor has been either accelerated or retarded, when the effort always surpasses the absolute requirement, and the speed attained pulsates between too fast and too

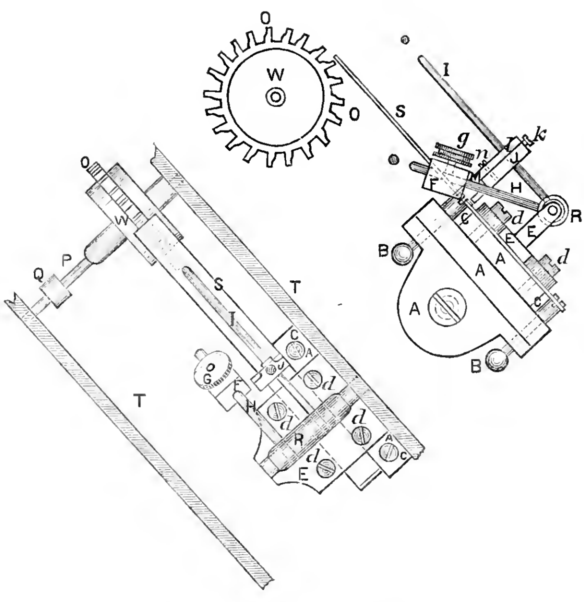
slow, never reaching exact uniformity; and the second in practice—in that rotary governors call for such dimensions of parts, and if acting by gravity such adjustment in position as to lose in a great degree the advantage of portability.

Without entering into the consideration of this subject of government by the rotary pendulum any further, I will proceed to describe another method which has given admirable results. The Hipp spring regulator has for its principle of action the uniform vibrations of a body, which, transmitted to the air, give a musical sound of some definite note. The lectures on acoustics, by Prof. Houston, last season, have familiarized most of my hearers with the knowledge that the arms of a tuning fork, in emitting its musical note, make a certain number of vibrations each second. The sound may be louder or less pronounced, but the same fork always gives out the same note, that is, makes just so many vibrations in a given time—same as a pendulum, at any certain length, always makes just so many beats in a second; the loudness of the sound being a condition of the amplitude of each vibration. Thus, a spring of certain length and thickness, which makes 528 vibrations each second, will produce the musical note $\bar{c}$ of the gamut. These musical beats must be perfectly regular in their time, or their ability to impart and maintain the vibration belonging to any note to the air will cease; and it is, consequently, easy to detect by the ear the instant when the spring ceases to be musical, to give out a clear sound. These extremely small but perfectly regular beats are made, in Hipp's *chronograph*, to allow the escapement of a toothed wheel. I will refer again to the lecture of Prof. Houston, in which he exhibited what is known as "Savart's Wheel." The method by which this philosopher discovered that the beats of a spring coincided with musical sounds, was to revolve a toothed wheel against the free end of springs of different sizes. He then found that a certain length and thickness of the bar which formed the spring was requisite to allow the teeth—each one of them—to touch the spring when the wheel had some certain speed of rotation, and when the speed of the wheel and the dimensions of the bar were properly adjusted, then a musical note would be emitted. The converse of this principle holds good, as Hipp's chronograph demonstrates, with a given spring, a toothed wheel, impelled by a certain force of small amount, by means of a spring or weight, will pass the free end of a spring, which may be

made adjustable in length so as to give any desired number of vibrations in a second, by the escapement or passage of a tooth at each vibration. Any uniform vibration whatever, emits or produces a musical sound. The only condition of a note of music is that of uniformity of time of vibration, while a musical *instrument* consists in certain relations of the numbers of vibrations of two consecutively sounded notes, so that their vibrations shall coincide at short intervals, so that the ear *measures* the length of one set of vibrations by that of another set of vibrations. This measurement, by coinciding vibrations, is what constitutes the mental appreciation of melody.

But a perfectly uniform series of vibrations will produce what will be recognized at once as a clear and distinct musical note, and 528 of such vibrations each second will give the note of $\bar{c}$, now accepted by musicians as the *pitch*. A tuning fork adjusted to give this note will produce no other, however hard or lightly it may be struck.

FRONT VIEW.
Section between the Plates.



PLAN (Diagonal Projection).
HIPP'S CHRONOGRAPH.
Scale, One-half Size.

The accompanying figure shows the escapement of a Hipp's chronograph, in the Swiss department of the U. S. International Exposition. As the spring and its adjustable parts were placed diagonally at an angle of 45°, it was necessary, in making a top view, which should not be distorted, to *project* a plan on the *diagonal*.

This unusual arrangement of drawing will call for a somewhat close examination to be understood, but it really presents a correct plan of the parts. The same letters on the several parts shown on view or plan, refer to the same pieces. The spring, indicated by *S*, is clamped to a rocking saddle *A*, which is secured to the plate *T* by the large screw, the head of which shows in the view, and is adjusted by the set screws *c c*, which impinge on some studs *B B*, that are set in the plate *T*; by this means the end of the spring is adjusted for contact with the escapement wheel *W*. The clamping piece for the spring is the rider *E*, and the four screws, *d d d d*, effect the clamp. This rider *E* carries a spindle *R*, which has two arms, *I* and *H*. Upon the arm *H*, there is placed a sliding head *J*, which is set when desired, on the arms by the screw *k*. This head carries a bit *m* of rubber or hard cork, which rests upon the spring *s* (*m* is clamped to *J* by the plate *l*, held by the screw *n*), and only that part of the length of *S* which projects beyond *M* is free to vibrate; consequently, the moving of the head *J* will control the number of vibrations by lengthening or shortening *S*. The second arm, *H*, carries the weight *F*, which is adjusted in place by the screw *G*. The action of this weight is to give the proper value of the pressure of *M* and by increasing the labor of the elasticity of the spring to lengthen the time of vibration. *O O* are the teeth of the wheel, *P* is the shaft, and *Q* is the pinion which gears into the train of impelling wheel-work. In the instance here chosen there were twenty-one teeth to the escapement wheel, and the driving mechanism was 1 to 7 for the first pinion and wheel, and 1 to 10 for the second pinion and wheel; while two revolutions each second, of a pair of rollers, drew forward a riband, which then received the mark of the second's interval of time from an independent pendulum clock. It follows that this spring would make about 735 beats per second. $\bar{f}$ sharp of the scale is about 745 beats.

In practice with a Hipp spring escapement the tooth does not rest upon and vibrate with the spring, so as to form a positive escapement each vibration, but the spring is adjusted just to clear the teeth of the wheel when the wheel is at rest, and the air between the teeth becomes the controlling agent, checking the rotation but not stopping or giving an absolute recoil at any instant.[1] The drawing

[1] Prof. Hilgard says: "Although it is a good adjustment for the spring to be just clear of the tooth when at rest, the extremity of the spring actually vibrates above

shows the position of the spring in the later instruments of Hipp's own construction.

From information derived from Prof. J. E. Hilgard, U. S. Coast Survey, I am able to say that much experience has been had in that Department in the use of Hipp's chronograph. They have three sizes; the smallest is regulated by a spring making 1000 double vibrations per second; the medium makes 560; the largest only 280 in the same time. A sheet from a cylinder chronograph, the barrel of which is 20·3 inches in circumference, and having upon it 60 seconds for each revolution and the lines of 99 minutes, shows the entire deviation in the entire time to be one and a half seconds. The cylinder machine presents great advantages in exhibiting the deviation from perfect uniformity, or the failure to effect a perfect adjustment of second's lengths with the revolutions of the cylinder. Thus the sheet in question shows that for 33 minutes there was a regular gain of one second during the time, the line of second marks advancing so to form a straight line inclined to the axis of the cylinder, and gaining one second's length in 33 revolutions; thus exhibiting that each minute was one-thirty-third of a second too long. The regularity of this condition throughout the entire revolution, second by second, shows that each second was 1–2000th the part too long,—the half of a vibration of the shortest regulating spring in error.

In the Appendix, No. 18, of Coast Survey Report (1872), will be found a method of adjustment of the length of spring while the chronograph is at work, proposed by Mr. Wm. Eimbeck, sub-assistant U. S. C. S. Mr. Eimbeck mounts the bit *M*, which adjusts the length of the spring *S*, with all its parts (which he modifies considerably), on a sliding frame (in lieu of on the rider *E*), which frame he moves endwise by a screw. The modification of the parts referred to, consists mainly in substituting a spring for the weight *F*, which spring is adjusted by another screw. As a result he was able to change the rate of the machine instantly—while running—to from one revolu-

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and below the point of the tooth where the chronograph is running; now whenever it strikes down clear of the tooth, the train will go on accelerating until the point of the next tooth will strike the spring as it comes down. This will check the train for the instant, after which the spring vibrates freely again until another, similar, acceleration has been reached. Each of these contacts makes a perceptible beat in the hum of the note. The more nearly the train is running to the time of the spring the less frequent they are, but of course the train *must* be always over-driven."

tion to two revolutions of the cylinder per minute—thus attaining the number of vibrations of the spring per second as two to one. The number of turns of the screw, in making the change, was determinable, and once found, "the various adjustments could be made without the slightest interference with the running of the chronograph." According to Mr. Eimbeck "the point of pressure upon the governing spring, when once adjusted, should remain perfectly constant."

While the chronograph now described has heretofore been applied only to use for astronomical observations, and to the determination of the velocity of projectiles,[1] I have brought it forward at this time principally to consider its application to some demands in mechanical industry and engineering science. It is well known to engineers that the ordinary reciprocating steam engine gives an irregular motion controlled first by the fly wheel which is alternately the driver and the driven during parts of each single stroke, and next by the governor, which is always endeavoring to slow the engine when it runs too fast, and to accelerate it when it runs too slow, and is totally inefficient in *preserving* equality of movement. It has long been desirable to possess some instrument which would exhibit the inequalities of movement of an engine. For the purpose of spinning fine yarn, for instance, it has come to be thought that the requisite uniformity of motion can only be derived from a water-wheel. A main pulley, whose surface speed will vary as 4 to 5 during the stroke and as 4 to 5 again in consecutive revolutions when running accurately 60 (or some other definite number of) revolutions per minute, is nearly as unsuited to produce nice work as such a pulley driven by an engine, whose speed shall vary as 16 to 25 revolutions per minute.

The principle of construction of a chronograph for engine testing is that of comparison of two motions, one of which shall be uniform and the other irregular or variable. The usual method is to rotate a paper covered cylinder at uniform speed of rotation in front of a pencil which is made to travel by a screw or feed, driven by the engine (or motor being tested). Suppose the cylinder to be 10 inches in circumference and to rotate by its own power once in a revolution of the engine, and suppose the pencil to traverse 10 inches in the

[1] Prof. Hilgard informs me "that I once had a chronograph built for the Navy ordnance department, on which the seconds were 30 inches long—correct to, say, 1-5000th of a second—it would only run five minutes at a course."

same revolution, being driven by the engine itself, it will then follow that the path of the pencil on the paper,when the covering of the cylinder is unrolled or developed, will be a straight line, if both motions are perfectly uniform. Whatever deviation from a straight line may be found in the tracing, will indicate the irregularities of speed, and establish their exact amounts. This same condition subsists, without regard to any relation of rotation of the cylinder to that of the engine, and the same principle holds good if the uniform motion be given to the traversing pencil, and the cylinder be driven by the motor to be tested. Where the engine marks each revolution automatically on a cylinder revolving at a definite rate, the variations of consecutive revolutions will be indicated by the position of the marks on face of the cylinder.

Not only the rotating engine requires this chronograph test, but it is equally, if not more essential for the exhibition of performance of the pumping engine of the non-rotating type. The chronograph of Gen. Morin,[1] with a fly regulator, was employed in 1843-4 in showing the velocities of piston for the Cornish engine at Old Ford (Pole on the Cornish engine, fo. 210, *et. seq.*), and a similar discussion should accompany each scientific investigation of a pumping engine. With this indication of the capability of the Hipp chronograph for practical mechanical use, I will close my remarks upon it.

It is proper, however, that I should, by way of comment, allude to the successful measurement of yet smaller intervals of time by Mr. Robt. Sabine. Mr. Sabine uses the constancy or uniformity of flow of an electric current produced by a given battery, and encountering a definite resistance; and by its means has measured, with certainty, less than the 1-100,000th part of a second of time, and with his apparatus has actually measured the duration of a blow upon an anvil. In the JOURNAL for December will be found a

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[1] See Nouvelles Experiences sur la Frottement par Arthur Morin, Capt. Art., fo. 19, *et. seq.*, for descriptions and drawings of this apparatus; and Report British Association, 1844, fo. 90, for circumstances of its application.

"A circular disc covered with card or paper, is made to revolve with uniform motion by means of a clockwork regulated by air valves. Upon this disc a revolving pencil whose motion is caused by, and corresponds with, that of the body whose variable velocity is to be measured, describes a curved line; from this curve the velocity may be ascertained."

paper [taken from *Engineering*, London, Oct. 27, 1876] by Mr. Sabine, giving the details of a series of experiments; to this paper I refer my hearers; and for a more complete description of Mr. Sabine's methods, a reference to the original paper in the *Philosophical Magazine* for May, 1876, will be advisable.

TONOMETRY.

By A. J. Ellis.

[From the *Athenæum*, London, December 2d, 1876.]

The Problem of Tonometry is: given a sustained musical tone to determine the number of vibrations made in one second of time by each particle of air, conveying the undulation to which the sensation of sound is due. By a vibration in France is meant the motion from the extreme position on one side, to the extreme on the other, like the single swing of a pendulum. In England, and now in Germany, by a vibration is meant the motion from the extreme position on one side, to the return to the same position, like two swings of a pendulum. *This* will here be always understood by the term vibration, and the former will, when necessary, be distinguished as a simple vibration. Tones are simple when the motion of the air follows the law of a pendulum; and compound in other cases. Compound tones are heard as if a certain number of simple tones (called partials) were sounded simultaneously. In this case the pitch is the number of vibrations made in one second by the lowest partial.

The old attempts at tonometry were made by a monochord, which was horizontal, or, much better, vertical,[1] stretched by a weight mathematically determined by the transverse section and specific gravity of the string, and limited by a fixed bridge at one end, and a movable bridge at the other. The pitch could then be calculated from the measured length of the string. More recently the siren, in which a perforated plate was driven by a stream of air with increasing, but constantly measured velocity, producing a constantly higher note, has been extensively used. The pitch of the given note had

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[1] Smith's "Harmonics," and General T. Perronet Thompson's "Just Intonation."

to be determined by the estimation of the ear as to when the monochord or siren gave a note identical with that under examination. All these methods are liable to numerous errors, and practically their results cannot be depended on to 10 vibrations in one second. Other methods were still worse.

Tonometry was first placed on a scientific basis in a badly written, but extremely valuable, little pamphlet of 80 pages and 4 lithographic plates, published at Essen, 1834. This pamphlet was entitled "The Physical and Musical Tonometer (*Tonmesser*), which proves by the pendulum, visibly to the eye, the absolute vibrations of tones, and of the principal general of combinational tones, as well as the most definite exactness of equally tempered and mathematical chords, invented and executed by Heinrich Scheibler, silk-ware manufacturer in Crefeld." [Crefeld is a town of Rhenish Prussia, twelve miles north-west of Düsseldorf, celebrated for its silk factories.] The principle upon which Scheibler proceeded was this. Tones which differ by a small amount "beat" together,—a very familiar phenomenon—varying from a slow wave to a rapid rattle; and the number of beats in a second is precisely the same as the difference in the numbers of vibrations which the two tones make in a second. A tuning-fork will also beat with an imperfect octave above it, and then the number of beats is the difference between the number of vibrations of the upper tone, and double the number of vibrations of the lower tone. Thus 256 and 259, or 256 and 253, beat three times in a second; and 256 and 515, or 256 and 509, also beat three; that is, the beats do not show whether the upper note is too sharp or too flat. This has to be ascertained by flattening the upper tone (placing the upper tuning-fork under one's arm for a minute or two is sufficient); if then the beats diminish in number, the upper note is brought more in tune, and was too sharp; if the beats increase in number, the upper note is brought more out of tune, and was too flat. For compound tones, other intervals can be selected, as shown below.[1] Then two forks being tuned roughly to (say) A on the first line on the bass staff, and

[1] Let the ratio of any perfect interval be $m : n$, n being the greater number. Let two compound tones, having the vibrations y and z, and audibly possessing the nth and mth partials respectively, form exactly this interval, then $m : n :: y : z$, or $mz = ny$, and no wave is heard. If they do not exactly form the interval, the difference of mz and ny gives the number of "beats of error," as distinguished from the "rattle of the beating partials," which always exists more or less distinctly in "reedy" tones.

the A above it, the upper A is flattened till it beats exactly 4 times in a second with the lower. (This is the easiest number to count. Generally either a very exact compensating metronome has to be used, or the beats must be counted through 10 to 100 seconds, and then the number of beats divided by the number of seconds. Less than 1 and more than 6 beats in a second are difficult to count with certainty, more than 8 almost impossible.) A third fork is now tuned 4 beats (in a second, as must be always understood) sharper, and will give the exact octave of the lowest fork, without any wave or error. Then proceeding downwards by 4 beats at a time we reach a fork which beats sharp 4, or less than 4, times with the original fork, and these beats are accurately counted. The sum of all the beats of all the forks, two and two, from the lowest to the highest, is necessarily the exact number of vibrations of the lowest, because these beats represent the number of vibrations to be added to the lowest in order to produce its octave, the highest, which has twice as many vibrations. Thus, the absolute pitch is known of all the forks used, and forks can be tuned to any intermediate pitch by less than 4 beats in a second. The construction of such tonometers of forks, large in size, never touched by the hand, kept at a constant temperature, and anxiously observed and re-observed, is a matter of great difficulty. Scheibler's original tonometer had 52 forks extending from A $219\frac{2}{3}$ (that is the note called A, and making $219\frac{2}{3}$ vibrations in a second) to A $439\frac{1}{3}$, but proceeding by unequal numbers of beats. Koenig, of Paris, subsequently improved on this by making one of 65 forks from C 256, to C 512, proceeding by 4 beats, and added two other forks F $341\frac{1}{3}$, and A $426\frac{2}{3}$. This is priced in his catalogue of 1865 at 2,000 francs, or 80*l.* Scheibler's own tonometer was made in 1834, by Kämmerling (long since deceased), in Crefeld, for sixty dollars, or 9*l.*, paid at time of ordering (*Tonmesser*, p. 80).

These instruments, with proper precautions, do excellent work. But they are cumbrous, costly, excessively variable with temperature, extremely mild in quality of tone, which prevents verification by any interval but the octave; with notes difficult to sound more than two at a time, and difficult to flatten and restore to pitch rapidly. These inconveniences are practically overcome by the tonometer made by Georg Appunn and Son (of Hanau, Hessen-Cassel, near Frankfort-on-the-Main), now in the Loan Collection of Scientific Apparatus at South Kensington, and priced, as I find on inquiry (it is as well to

state that I have none but a scientific interest in the apparatus) at 360 German marks, or 18*l.*, without the blowing apparatus, which adds about 6*l.* or 7*l.* more. It is of small and comparatively convenient size, and its tones are not nearly so much affected by change of temperature as those proceeding from tuning-forks. The notes are extremely reedy in quality of tone, so that the 16th partial can be made effective, and hence all intervals used as verifications. The notes are also easy to sound and to damp in any number at a time; and to flatten, any one separately and instantly or gradually, by 1, 2, or even 3 vibrations, and to restore immediately to the former pitch. This last is one of the most important properties of the instrument. It consists of 65 harmonium reeds, actuated by pulls numbered 0 and 1 to 64, which when pulled out completely give the true tone, and when gradually pushed in, gradually flatten the tone. The pitch is from c 256 to c 512, increasing regularly by 4 vibrations.

Using this instrument to measure forks, I found great discrepancies between the numbers shown and the numbers stamped on the forks. For my own satisfaction, therefore, I verified the instrument as follows. First I counted the beats with a pocket chronometer between pulls 0 and 1 for 15 seconds, and found them 60, or 4 in a second. Next I counted the beats between each pair of the other adjacent pulls for 20 seconds, and found them always 80, or 4 in a second. Hence the whole increase was 4 times 64, or 256 vibrations. I then examined, first, the usual consonances on the instrument, consisting of 1 Octave 1:2, 11 Fifths 2:3, 11 Fourths 3:4, 10 major Thirds 4:5, 9 minor Thirds 5:6, 4 major Sixths 3:5, 4 minor Sixths 5:8; secondly, the septimal consonances, 6 sub Fifths 5:7, 4 super-major Thirds 7:9, 8 sub-minor Thirds 6:7, 3 sub-minor Sevenths 4:7; and thirdly, the usual dissonances, having audible identical partials, 7 major Tones 8:9, 5 minor Tones 9:10, 4 diatonic Semitones 15:16; or 87 just intervals on the whole. For every one there was the proper rapid rattle of beating partials, but not the slightest wave of error in the identical partials. This wave was, however, instantly produced by flattening the upper reed, and made to disappear by flattening the lower reed at the same time to the proper extent, and to reappear by flattening the same more. I have, therefore, a mechanical guarantee that every one of these intervals was correctly represented on the instrument. But every one of them separately proved, after counting the beats, that the lowest tone made 256 vibrations in

a second, and the whole set by their perfect agreement proved that the beats had been correctly counted.[1] The introduction and extinction of the beats of error were often very remarkable. Thus the diatonic semitone, pulls 11 and 16, with 300 and 320 vibrations, when the upper note was flattened, beat in error with 4,800, and the same slightly altered; that is, a D' *sharp* above the ninth leger line above the treble staff, and the same slightly altered. This slow beat of error was distinctly separable from the rapid rattle of the beating partials, including the lowest and strongest. By conscientiously trying every one of these 87 cases, I have convinced myself of the perfect trustworthiness of the instrument, and those to whom I have shown some of them, have been equally convinced, among whom I need only mention as most competent to decide, Mr. A. J. Hipkins of Messrs. Broadwoods, and Mr. E. Greaves of Sheffield, a large maker of tuning-forks for Messrs. Broadwoods, and the whole music trade, who has now accepted the 256, 384, and 512 of Appunn's instrument, as absolutely correct, and copied them on forks.

An examination, by means of this tonometer, of a number of standard forks, developed some remarkable results. [It is stated that the pitch of the Paris opera, 1699, was A 404, C 480·44, and it is quoted here as the lowest pitch on record, but the correctness of the statement is questionable.] Handel's fork, 1751, gave A 426·4, C 507·14—this fork was used at the Foundling Hospital, when the Messiah was performed, and a contemporaneous note stated, "Antient concert, whole note higher; Abbey, half tone higher; Temple and St. Paul's organs exactly with this pitch." A series of other forks from the best authorities, proved to vary in small amounts from their supposed values, and compared when reduced to Cs 510·1, 512, 515·82, 517, 517·25, 518·52, etc.; while a French normal, which should have been A 435, proved A 439, C 522·06. Close to this figure comes

[1] Let x be the vibrations of the lowest note, p and q the beats added by pulls P and Q, found by counting, so that the reeds actuated by P and Q gave $x+p$ and $x+q$ vibrations, and let $m:n$ be the ratio of the interval. Then, by the preceding foot-note, $n(x+p)=m(x+q)$, or $(n-m)x=mq-np$, which gives the value of x in each case. Thus pulls 10 and 47 give a Fifth $2:3$, and counting gives $p=4\times10=40$, $q=4\times47=188$. Hence $(3-2)\ x=2\times188-3\times40$, or $x=256$, and so for all the 87 cases. Had there been any error in counting, it would have been detected by one or more of these cases not giving $x=256$. Of course, these perfect intervals render the instrument invaluable to any teacher of musical acoustics.

the fork of Sir George Smart, c 521, Messrs. Broadwoods' "low pitch" c 523. The "Stuttgart pitch" c 523·25, the Vienna orchestra, 1834, c 524·29. [The Soc. of Arts' standard, which is theoretically c 528, but which was never made, can be compared to these last results.] And finally, there was tested a series of higher forks, Broadwoods' medium c 535, and others, of which Sir M. Costa's Philharmonic Wind Band Concerts of c 542·5, and Broadwoods' high-pitch c 545·2 are examples.

The above statements having been carefully read over to Mr. A. J. Hipkins, he concurs in the accuracy of all that relates to himself, and to the forks in possession of himself and Messrs. Broadwoods, which he obligingly brought to me for measurement. It is hoped that the above measurements, and especially Appunn's convenient tonometer, a copy of which should be in all musical centres, will contribute to settle the question of Standard Pitch in England. It will be seen that the real French normal A 439 = c 522, and Scheibler's A 440 = c 523$\frac{1}{4}$, and Messrs. Broadwoods' "low pitch," c 523, seem to unite the greatest number of pitches in actual use.

CERTAIN POINTS IN THE DEVELOPMENT AND PRACTICE OF MODERN AMERICAN LOCOMOTIVE ENGINEERING.

By Francis E. Galloupe, S.B.

Continued from Vol. ciii, page 28.

The Efficiency of the Heating Surface is equal to the ratio of the difference of temperature of the hot gases on first coming in contact with it, and on leaving it, to the amount of heat transmitted by it to the water; or, calling T_1 the temperature of the hot gas at first, T_2 its final temperature, and t the temperature of the water, its efficiency, $e = \dfrac{T_1 - T_2}{T_1 - t}$.

The efficiency of the furnace is the proportion that the available heat from one pound of fuel bears to its total heat of combustion. The laws of combustion are fixed and definite, and the boiler should be so proportioned as to conform to them. With the heating surface, however, it is found that no two portions have the same efficiency. The efficiency depends upon a number of conditions, the extent of

surface, its position, the nature and thickness of the conducting material, the difference of temperature, the time allowed for the transmission, the nature of the heating substance, whether heated gas, flame, or incandescent fuel, and the manner in which the heat is communicated, by conduction or radiation. In regard to the first two of these it has been found[i] by Mr. Armstrong, that "a cubical metallic box, submerged in water, and heated from within, generated steam from its upper surface more than twice as fast per unit of area, than it did from the sides when vertical, and that the bottom yielded none at all." From this experiment, and others by C. W. Williams, and D. K. Clark, upon the diminished heating effect of successive portions of the tubes, it is found that the crown sheet and furnace tube plate are the most efficient, a square foot of the fire-box area being equivalent to three of the tubes. The latter are placed in vertical rows, with $\frac{5}{8}$ inch water space between them, and from the above, it will be seen that the bottoms of the tubes, or one-fourth of their circumference, have, practically, no heating effect, while the sides together are only equal to the top, so that, really, we may consider but one-half of the tube area as effective as the fire-box. The equivalent heating surface in the tubes would therefore be but 463·6 instead of 927·3 square feet.

Practically, in estimating the heating surface, three-fourths of the tube area are included, neglecting only the bottom, so that in this boiler we may correct the value of the total heating surface found, and by doing this we have the *effective* heating surface,

$$= \tfrac{3}{4} \times 927{\cdot}295 + 97{\cdot}59 = 695{\cdot}47 + 97{\cdot}59 = 793 \text{ square feet,}$$

which agrees very well with that given by the rule, or 742.

The theoretical consideration of heating surface, and the transfer of heat through it, forms one of the most profound and complex, and at the same time interesting, subjects in physical science. I shall then be obliged to state here only results, without giving, in extent, the reasons on which they have been based. The rate of conduction of heat through a boiler plate, or the number of thermal units transmitted per square foot of area per hour, is dependent upon the rate at which the temperature varies along a line perpendicular to the section through which the heat is transferred,[ii] and upon the

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[i] Tredgold, on the "Steam Engine."

[ii] Rankine.

resistance of the material to its transfer, or upon what is called the coefficient of internal conductivity.

The quantity of heat conducted is directly proportional to the area of the conducting surface, the length of time, and difference of temperature between the two sides of the plate, and inversely as the thickness of the plate, and as the coefficient of resistance of its material, if by this we denote the reciprocal of the coefficient of conductivity. Now the resistances are made up of three factors; that of the transfer of heat from the hot gases to the plate, upon one side; the internal resistance of the plate; and that of the transfer to the water upon the other; and denoting these by r, r^1, and r^{11}, respectively, we have Rankine's formula for the rate of conduction per square foot of heating surface, $K = \frac{T^1 - T}{r + r^1 t + r^{11}}$, t denoting the thickness of the plate. Since the external resistances greatly exceed the internal, the latter is neglected, and in a formula based on one deduced by M. Peclet, and agreeing with the best practice, Rankine gives the external resistance, $r + r^{11} = \frac{a}{T^1 - T}$, where a is a constant, the mean value of which is 180. Assuming that the hot gases escape from this heating surface at a temperature of 600°, which is the maximum, and also the temperature which would produce the best natural draught, and that the temperature of the fire is 3044° Fahr., the rate of conduction through a square foot of plate is found to be $K = \frac{(T^1 - T)^2}{a} = \frac{(3044 - 600)^2}{180} = 33{,}184$ thermal units per hour. Or, if the heat was fully utilized, since the temperature of the escaping gases cannot be lower than the temperature of the water, and this, for 140 lbs. steam pressure, is 360·595° Fahr., the rate of conduction could not be more than

$$\frac{(3044 - 361)^2}{180} = 39{,}436 \text{ thermal units per hour.}$$

The efficiency of the entire heating surface, obtained by integrating the value of $\frac{T_1 - T_2}{T_1 - t}$ for each minute area ds, of the heating surface, and inserting the relations found in the formula explained above, can be proved to be equal to this expression, given by

Rankine, $e = \dfrac{S}{S + \dfrac{a\, c'^2\, W^2}{H}}$, in which a is a constant; c', the specific heat of the gas at constant pressure; W, the weight of gas given out in an hour; H, the total expenditure of heat per hour, and S, the number of square feet of heating surface. Since the amount of heat $c'^2\, W^2$ is proportional to $V_0^2\, F^2$, where F is the number of pounds of coal burned in the furnace per hour, and V_0 is the volume of air at a temperature of 32°, supplied per pound of fuel, Rankine represents the efficiency of the furnace, or the ratio of the available to the theoretic evaporative power of the coal, by an equation of the following form: $e = \dfrac{E^1}{E} = B\, \dfrac{S}{S + A\, F}$, which is the best formula known by which to obtain the practical efficiency of the furnace. In this, of the constants, which have been determined empirically, $A = \cdot 3$ for an ordinary convection and forced draught; B is a fractional multiplier to allow for miscellaneous losses, and which, with the best convection and forced draught, is unity; but for ordinary convection is $\frac{19}{20}$, 5 per cent. being deducted for these losses; and F and S may be taken per square foot of grate area.

The maximum rate of combustion in locomotives is about 125[1] lbs. of coal per square foot of grate per hour, $= F$. When the maximum or total amount of heating surface is used, $S = \dfrac{1025}{14{\cdot}84} = 69{\cdot}2$. The ratio, $\dfrac{S}{F} = \dfrac{69{\cdot}2}{125} = {\cdot}55$, and the corresponding efficiency, ·59.

The corresponding evaporative power from 212°, in which case the total theoretic evaporation E, has been found to be 13·82 lbs., is $E^1 = E \times e = 13{\cdot}82 \times {\cdot}59 = 8{\cdot}15$ lbs. of water. From 62° Fahr., and at atmospheric pressure the evaporative power is

$11{\cdot}97 \times {\cdot}59 = 7{\cdot}06$ lbs. of water.

Another way of calculating the efficiency of the furnace is from the initial and final temperatures of the products of combustion, $\dfrac{T_1 - T}{T_1} = \dfrac{3044 - 600}{3044}$, which gives 80 per cent. for the efficiency, but this is a theoretic method, and the actual in nowise approaches it.

The more actual case, I think, would be to take the effective heating surface, 793 square feet, in which case,

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[1] Forney.

$$e = \frac{E^1}{E} = 1 \frac{53\cdot6\left(=\frac{793}{14\cdot84}\right)}{53\cdot6 + 37\cdot5} = \cdot586 \text{ for the actual efficiency,}$$

and if we deduct $\frac{1}{20}$ of this for the waste in unburned fuel, unburned gases and smoke, waste by radiation, conduction, etc., we have the ordinary efficiency of the locomotive furnace, ·557.

Taking the total heat of steam at 140 lbs. pressure at 1223·92 thermal units, and dividing the total heat of combustion of one pound of Cumberland coal, 13,363, by it, we find 10·92 lbs. of water to be the theoretic evaporative power, and the evaporative power that we should expect this boiler to exhibit, under the usual pressure of 140 lbs., would be $E^1 = 10\cdot92 \times \cdot557 = 6\cdot08$ lbs. of water per pound of coal.

Boiler Power, or its steam generating capacity, depends upon the grate area, the extent of heating surface, the draught, conducting power, and the quality of the fuel. Its available power also depends upon the application of the steam after it leaves the boiler. The horse power depends upon the amount of water it can convert into steam in a certain time, and this, in turn, is directly proportional to the amount of coal that can be burned on the grate. The maximum amount that this boiler can be expected to burn per hour is therefore $125 \times 14\cdot84 = 1855$ lbs.

Now in the 16×24 inches cylinder there are 4825·4976 cubic inches, or 2·792 cubic feet. If solid cylinders full of steam are used, these must each be filled and emptied twice in every revolution, or the amount of steam required will be $2\cdot792 \times 4 = 11\cdot168$ cubic feet. Suppose one of the conditions in the problem stated at the beginning of this part, to be a required speed of 25 miles per hour, which is about the average on the Eastern R. R. In one mile there are 5280 feet, corresponding to 88 feet per minute, so that the engine would have to move 88×25 miles $= 2,200$ feet per minute, and dividing by the circumference of the driving wheel, 16·36 feet, there would have to be about 135 revolutions per minute. Hence, $11\cdot168 \times 135 = 1507\cdot68$ cubic feet are used and must be supplied per minute.

The relative volume of steam, at 140 lbs. pressure, is 182·6. Therefore, $\frac{1507\cdot68}{182\cdot6} = 8\cdot26$ cubic feet of water to be evaporated per minute, which is equivalent to $8\cdot26 \times 62\cdot4$ (mean weight of a cubic foot of water) $= 515$ lbs., or 30,900 lbs. per hour.

As we have found, one pound of coal will evaporate 6·08 lbs of water under these conditions, and therefore $\frac{30,900}{6 \cdot 08} = 5082$ lbs. of coal would be burned per hour. Now it will be seen by the tables in Part II, that with the ordinary weight of train, the steam was usually cut off at 10 inches of the stroke. Therefore, if only $\frac{10}{24}$ of the steam is used, the amount of coal necessary to be burned would be less, or $\frac{10}{24}$ of $5082 = 2118$ lbs., which we see is rather more than this boiler can consume under the conditions, its maximum rate being 1855 lbs. per hour.

III. With the *Feed Apparatus*, we leave the treatment of the boiler proper, and enter upon that of the numerous boiler attachments. These continue also through the two succeeding divisions. Mr. Forney, in mentioning the accidents liable to occur to locomotives, of which he enumerates nineteen of the more serious, estimates the order of their importance as, first, accidents occurring to the locomotive as a whole, such as collision, running into an open draw, escape of an engine without any one on it, and running off the track; second, accidents to the boiler, such as its explosion, bursting of a flue, or blowing out of a rivet; third, failure of the feed apparatus; and fourth, breaking of the mechanism, as the bursting of a cylinder or a cylinder head, breaking or bending a piston rod, connecting rod, crank pin, wheel, axle, or spring, so that the right working of the feed apparatus is of much more importance than even that of the mechanism, and, indeed, second only to that of the boiler itself.

The feed apparatus, for the supply of water to the boiler, consists of a single acting plunger pump, and the injector. Sometimes the injector is dispensed with, and then the rule seems to be that there should be two pumps, each of which is of sufficient capacity to supply the boiler. In practice the apparatus used for the steady feed, or main supply, whether it be pump or injector, is placed upon the engineer's or right side of the engine looking forward from the cab. From the specification we see that the pump occupies this side, and is that which is in constant use while running, while the injector is only used at stations, or in case the pump or its connections should fail. The general arrangement of the pump feed is shown on plate *A*, its details on plate *B*. It consists of a plunger, $1\frac{7}{8}$ inches in diameter, working in a brass cylinder, its motion being derived directly from the cross-head, a set of pipes, cocks, and three valves of similar construc-

tion, called, in reference to their position, the *suction*, *pressure*, and *check* valves.

On opening one of the cocks marked *A*, upon the tender, in plate *E*, the water flows along the horizontal pipe shown in the general view, and enters the vertical apparatus shown in Figs. 34 and 33, at *B*. The two rounded vessels at either end of this act as air chambers, and between them the plunger, Fig. 35, works back and forth in a horizontal direction. On the first stroke, the plunger enlarges the capacity of the pump and its connections by its own volume and tends to create a partial vacuum; hence the water flows in and upward through the lower vessel, enters the pipe *D*, Fig. 33, compresses the air in the annular portion *C*, and passes upwards through the suction valve at *E*. The three valves all open upward with an amount of lift from $\frac{3}{16}$ to $\frac{1}{2}$[1] an inch, are placed in brass cages, which allow only the necessary amount of motion.

On the return stroke, or stroke number two, of the pump plunger, the suction valve closes, the water is forced through the pressure valve, *F*, by the mouth of the upper air chamber, *G*, along the curved pipe, *H*, shown in the general view, through the check valve, *I*, shown in plate *A*, and plate *B*, Figs. 29, 30, and 31, and into the boiler at a point just below the mean water level.

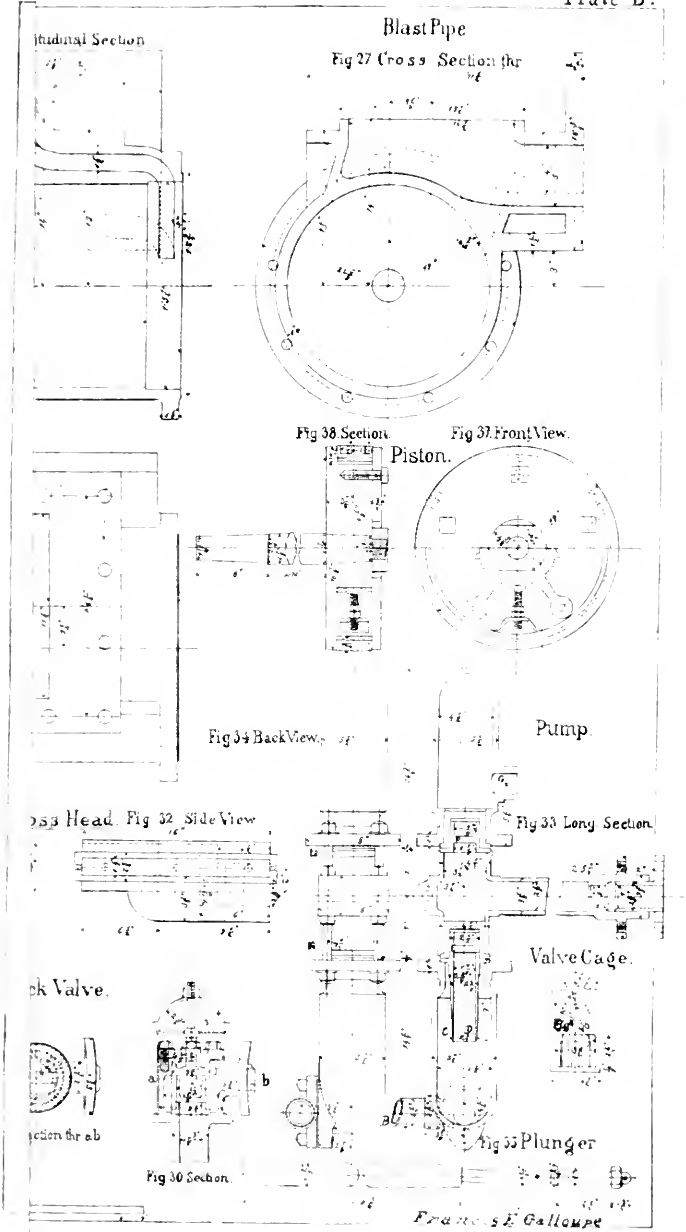
The manner in which the pump is put together is clearly shown in the drawings; in Fig. 34, the parts are held together by the bolts *K* and *L*, unscrewing which gives access to the suction and pressure valves, respectively.

The pump at every point has an elastic medium against which to act. The energy exhibited in the velocity of the moving column of water, on entering, is taken up by the compression of the air in *C*. On the return stroke, the direct pressure is equalized by the upper air chamber, and at the check valve it has the elastic cushion of the steam in the boiler. Without the useful recoil of the springs which these constitute, we can hardly estimate the shock, or water hammer, which would be produced at each reversion of direction of the pump plunger, taking place, as it does, *six times a second*, at ordinary speeds, and sometimes *ten* or *twelve* times.

The supply of water fed to the boiler is regulated by a feed cock in the suction pipe. To ascertain whether the pump is working or not, there is a small but very useful appliance, which was invented

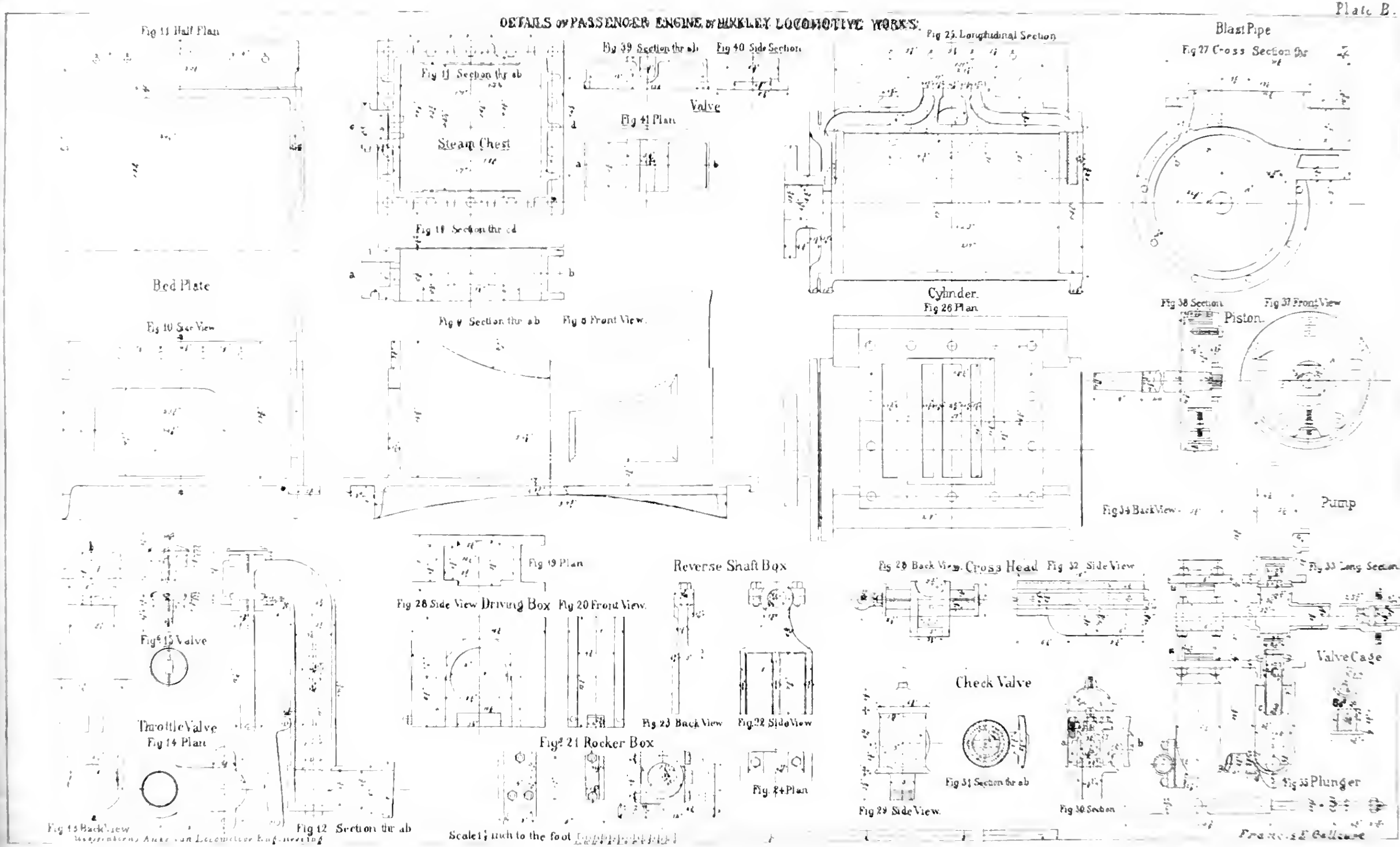
[1] Forney.

Plate B.



Blast Pipe
Fig 27 Cross Section thr
itudinal Section
Fig 38 Section
Fig 37 Front View
Piston.
Fig 34 Back View
Pump.
Fig 33 Long Section
Head. Fig 32 Side View
Valve Cage.
k Valve.
ection thr ab
Fig 30 Section
Fig 35 Plunger
Francis E. Galloupe

Plate B.


DETAILS OF PASSENGER ENGINE OF HINKLEY LOCOMOTIVE WORKS.
Fig 11 Half Plan
Bed Plate
Fig 10 Side View
Fig 17 Section thr ab
Steam Chest
Fig 18 Section thr cd
Fig 9 Section thr ab
Fig 8 Front View
Fig 39 Section thr ab
Fig 40 Side Section
Valve
Fig 41 Plan
Fig 25 Longitudinal Section
Cylinder
Fig 26 Plan
Blast Pipe
Fig 27 Cross Section
Fig 38 Section
Fig 37 Front View
Piston
Fig 34 Back View
Pump
Figs 15 Valve
Throttle Valve
Fig 14 Plan
Fig 13 Back View
Fig 12 Section thr ab
Fig 19 Plan
Fig 28 Side View
Driving Box
Fig 20 Front View
Reverse Shaft Box
Fig 23 Back View
Fig 22 Side View
Figs 21 Rocker Box
Fig 24 Plan
Fig 28 Back View
Cross Head
Fig 32 Side View
Check Valve
Fig 29 Side View
Fig 31 Section thr ab
Fig 30 Section
Fig 33 Long Section
Valve Cage
Fig 35 Plunger
Scale 1½ inch to the foot

by George Stephenson, called a "Pet Cock," and which is placed in the lower part of the upper air chamber. This little affair, when opened, lets out suddenly a stream of water, on the inward stroke of the plunger, as its position would indicate, which shows, when weak, that the pump is imperfectly working. It further shows which valve it is that leaks, or has become obstructed, and when the pump is in perfect order, it is sharp and well defined. In cold weather the pump and connections are prevented from freezing, by pipes conducting steam from the boiler to the suction pipe, by means of which the water is heated.

If a locomotive, supplied only with pumps, should be snowed up, which sometimes occurs on the New England roads, it would be necessary to lift the engine from the rails so that the driving wheels could rotate, when the pump could be worked and the boiler supplied with water; but all this inconvenience and labor will be obviated if the boiler be fitted with that delicate instrument, whose principle will be next explained, called

The Injector. Of this instrument there are several different forms,—the Sellers', Mack's, Rue's, and Friedmann's patents, besides the original Giffard injector, which was first patented by Mr. H. J. Giffard, in England, July 23d, 1858. In their construction they are of four classes, the lifting, non-lifting, self-regulating, and fixed. The original Giffard injector has been in use in this country about fourteen years, and with the improvements that have been made in it, is the form manufactured by Wm. Sellers.

The size, or capacity of an injector is determined by the steam pressure and quantity of water evaporated per hour, or the horse-power of the boiler. As far as their working is concerned, they may be placed in any position, upright, on their side, or inverted. The non-lifting injectors are used mostly for stationary boilers, and when placed upon locomotives, must be placed so low between the wheels, that the water will run by its own gravity from the tender and fill the instrument. In the lifting class, the water is drawn up through a suction pipe, as in the pump. In the fixed nozzle injector, the instrument works perfectly at but one pressure, that for which it is designed, and in the self-regulating, it works easily at a great range in variation of pressure, but from the more delicate and complicated apparatus thus necessary, the fixed nozzle is often employed.

(To be continued.)

PRACTICAL TUNNELING.

[From the *Mining Journal*, Nov. 11, 1876.]

From the constant necessity for systematic tunneling operations in connection with the development of mining works upon the extensive scale usual in modern times, such works as Simms' Practical Tunneling[1] are almost invaluable. Mr. Clark remarks that as a monograph on tunneling Mr. Simms' work stands unrivaled, and it is as useful now as it was on the day it was first published. At the same time, since those tunnels were completed a great deal of valuable experience has been accumulated in tunneling, for many other tunnels have been constructed under different circumstances, and through ground of various geological formations. Other types of construction have been developed, of which it is scarcely necessary to state that the tunnel under the Col de Fréjus, commonly known as the Mont Cenis Tunnel, above 7½ miles in length, is the greatest and most wonderful achievement of the time. The engineering construction of the Metropolitan Railway, popularly known as the Underground Railway, in London, is a unique performance, which most men pronounced impossible before the event, and this great work is only less admirable than the Mont Cenis Tunnel. In the portion of the work added since the previous edition was issued the system of driving tunnels known on the Continent as the English and the Belgian systems—based on the bottom heading and the top heading respectively—are carefully investigated. Then follows a discussion of the ordinary casualties in tunneling, and is followed by details of the experience gained in tunneling in clay, marl, etc., in coal formations and in hard rock. The St. Gothard Tunnel, now in course of construction, which will when completed have a length of 9¼ miles, has been very fully described, the materials being for the most part drawn from the excellently prepared quarterly reports of the engineer.

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[1] A Review of a Book on "Practical Tunneling; Explaining in Detail the Setting Out of the Works, etc. By Frederick Walter Simms, C. E. Third edition, revised and extended with additional chapters, illustrating the recent practice of tunneling as exemplified by St. Gothard, Mont Cenis, and other modern works. By D. Kinnear Clark, M. Inst. C. E. London: Crosby Lockwood & Co., Stationers' Hall Court, Ludgate Hill."

From the introductory chapter it appears that the tunnel on the Languedoc Canal, commenced in 1666, was one of the earliest instances of this description of work. The Hartshill Tunnel, on the Chesterfield Canal, 3,000 yards long, and the Sapperton Tunnel, on the Thames and Severn navigation, $2\frac{1}{2}$ miles long, and lined with masonry, are amongst the earliest constructions in England. The method of proceeding with tunneling depends upon the kind of material to be excavated. The nature of the material is in ordinary circumstances ascertained approximately by means of boring and trial shafts, which are sunk from the surface over the axial line of the tunnel to be constructed through the intervening strata to the level of the lower part of the tunnel. Particular attention is required to be given to the practical geology of the material, whether rock, earth, chalk, or sand, and the skill of the engineer and the contractor is tested by the application of their knowledge of the subject to the development of safe and proper forms and proportions, as well as to the execution of the necessary works of construction. All unstratified rocks which are homogeneous and free from faults may be excavated, so as to leave the sides of the excavation vertical or nearly so, and thus a tunnel may be formed by merely driving a heading through the rock without the protection of an arch of masonry. It is generally only in such strata as clay-slate, granite, or other primary rock, that works can be left without artificial protection. In greissous formations the walls of excavations may stand and endure unprotected, whilst it may be judicious and even necessary to line the arch. Mica schist, on the contrary, and particularly when loosened by distortion, most commonly requires to be substantially lined above the floor with masonry. But many stones whose strength and texture would, if they remained unaltered by exposure, enable them to stand forever, are affected by atmospheric air and moisture, and very speedily so by frost. Decomposed granite, called by miners potgrowan, is extremely troublesome in mining; it consists principally of feldspar and potash, as does the china-clay or kaolin of the potteries. The substance appears to have been formed by the decomposing action of the air, or of chemically formed oxygen. Pyrites has a natural tendency to decomposition when exposed to the air, and it affects everything with which it comes in contact. Chalk is a material which, in those parts where it first crops out—that is, at the top of the stratum—has

frequently given much trouble by reason of its inequality, and the common occurrence of potholes of loose gravel which, when unduly charged with water, break away the surrounding chalk. The presence of chalk veins in the mica schist formations of the St. Gothard mountain have been found to expose the rock to decomposition when opened to the air by the excavation of the tunnel. The diluvial strata are from their nature the least compact, and therefore require the most careful treatment. The alteration, too, in their position, which at some remote period of time has uplifted and distorted the original horizontal strata, renders them liable to further change of form by facilitating the operation of water—the element to which they owe their formation originally, and to whose continued action they seem peculiarly susceptible. Of these formations the most solid are gravel and sand. The other soils of this class are extremely variable. Some clays are firm and tenacious, others of a marly character are slippery; while quicksands and peat are proverbially treacherous. Clays, too, may be intersected by porous veins, which acts as conduits for water. The London clay has a notorious reputation with well-sinkers; even in the absence of moisture, if the clay be left exposed to the air for a few hours it expands and bulges inward. A well at Richmond of 4 ft. diameter was completely closed in one night by the swelling up of the bottom, although there was not any water in it. In mining operations the expansion of clay is well understood. The floors of old mines are always expected to swell upwards. The action of the air upon shale is well known; shale, though so tough and hard underground as to require the agency of gunpowder for its excavation, swells when uncovered, and becomes after a few weeks' exposure to damp and atmospheric action thoroughly decomposed, and falls to powder.

In the main portion of the book the geological features of the South-Eastern Railway are described, and a general account is given of the Blechingley and Saltwood tunnels, the observations made by geologists during the construction of the line having permitted of a very accurate and complete statement being made. In the second chapter is a description of the transit instrument, and the method of fixing and adjusting it is explained, the mode of using the instrument and securing accuracy being described with equal care. Having described the method of keeping the works straight in a horizontal direction, he explains how to make it correct in a vertical

direction or preserve the proper level. The fourth chapter explains the methods of shaft sinking in connection with tunneling operations—the trial shafts being chiefly considered—whilst in the succeeding chapter the mode of excavating and constructing the working shafts and supporting the brickwork by shaft sills and hanging rods. There is an interesting chapter on driving the headings, and some valuable estimates of cost. It appears that by horse labor it costs 2·85d. per ton to lift water and stuff an average of 104 ft. There is a chapter on excavation and timbering, and others on putting in the brickwork and finishing the tunnel with the junction lengths. In the portion of the work contributed by Mr. D. K. Clark, the relative advantages under varying circumstances of the English and the Belgian systems—the bottom heading and the top heading—is discussed, and he remarks that the greatest disadvantage of the system of bottom headings and break-ups in certain grounds consists in the lengthened exposure of the surface of the excavation to the action of the air, which in clays, marls and shales loosens the ground, and in rock opens the fissures. A chapter is devoted to casualties in tunneling, which will prove of great practical utility in suggesting some of the obstacles likely to be encountered. The chapter on the enlargement of railway tunnels is of considerable interest, as showing the peculiar difficulties arising from the disturbance of soils which had already been disturbed, and more or less displaced before. In the chapters on tunneling in hard rock, reference is made to the tunnels on the aqueduct of the Glasgow Water Works, to the Clifton Tunnel, to the Mont Cenis, and to the St. Gothard, and with regard to the latter work very complete details are given both as to the compressors, drills, etc., used, and as to the results obtained.

The work altogether gives evidence of the editor having devoted a large amount of labor to the revision and extension of the original treatise, and as the details are given with much minuteness, especially with regard to the most recent and approved practice—those details being made remarkably clear by the numerous illustrations accompanying them, the engineer who takes the book for his guide need have little fear of falling into error, or of being unable to cope with the many obstacles he is sure to meet with in carrying out his work. It is a really valuable volume for reference.

TALL CHIMNEYS AND ELECTRIC CONDUCTORS.

From *Iron*, London, October 28, 1876.

There are few chimneys which have any peculiar historic interest, but an exception is presented in one built at Glasgow by Mr. Joseph Townsend, and attached to that gentleman's chemical works. This chimney is to its neighbors what Mount Blanc is to the rest of the Alps—a giant among pigmies. The foundation of this chimney was laid in March, 1857, and on the 6th of October, 1859, the coping was added at the top, at a height of 468 feet from the foundation, and 454 feet from the level of the ground.

At the foundation the outside diameter is 50 feet, and at the surface it has diminished to 32 feet, while at the top of the coping the diameter is 12 feet 8 inches. On the 9th of September, 1859, and while the chimney was still unfinished, and therefore before the mortar was dry, a storm occurred and resulted in swinging the chimney out of the perpendicular to the extent of 5 feet at the top. This accident, though perhaps directly due to the storm, had its origin in a neglect in the building process. Proper allowance had not been made for the contraction of the mortar used in setting the bricks, and as a consequence a certain number of planks were under a great pressure, being arched in the centre. Suddenly one of these at one side gave way in the oscillation caused by the storm, and with the unequal pressure the chimney was then forced from the perpendicular to the extent above stated. That the accident occurred in this way Mr. Joseph Townsend ascertained by personal observation. For a time some fear was entertained that the whole chimney would come down, but on the 21st of the same month measures were taken to prevent this, and by the 1st of October, the whole was restored to the original upright form. This was effected by sawing the chimney on the side nearest to an imaginary straight line. The following figures give the intervals at which cuttings were made:—

1	128 feet from the top			8	13 feet below		7
2	49 feet below		1	9	20	"	8
3	22	"	2	10	30	"	9
4	15	"	3	11	40	"	10
5	12	"	4	12	40	"	11
6	19	"	5	13	41	"	12
7	20	"	6				
					440 feet.		

When the chimney was only two years old, it was struck by lightning, and a fire ensued, the composition gas-tubing being melted at a distance of 100 feet from the gas meter, though this latter was situated 20 feet from the chimney. To understand how this happened, it is necessary to state a few additional facts. The chimney was provided with an electric conductor on one side, and a coil, which united with the conductor near the ground, where together they were bound to an iron rod and passed through a well of water, situated near the side of the foundation, 7 feet square and 2 feet deep, and thence down about 8 feet into the earth. Now, into this well comes the drainage of the works, and, further, the discharge pipe from a water closet, and it was found, on investigation, that although the pipe actually discharging into the well was of stoneware, yet, further back, it was in connection with one of cast iron. This latter pipe being midway between the conductor and the gas composition tubing, must have served as a vehicle for the electricity, which must then have completed its circuit by the gas pipe, which was thereby melted, and, the gas escaping, caused the fire.

To prevent a recurrence of such an accident, the cast iron pipe was removed and one of stoneware substituted. All now went well till three years ago, when the chimney was again struck by lightning at 150 feet from the top, 30 bricks being then dashed out. Again an examination was instituted and it was found that a separation had been effected between the conductor and the rod of iron with which it was bound where it passed through the well at the bottom. This separation had probably happened before the accident occurred and so possibly caused it. A new rod 10 feet long and passing 8 feet into the earth, was now substituted for binding the conductor and coil together, and the whole was well tallowed to prevent oxidation, and was finally enclosed in a wooden box, of which the side of the chimney made the fourth. But a year ago the chimney was once more struck by lightning on the opposite side to that which was last attacked, that is on the side along which descends the conducting rod. On this occasion a part of the coping stone was knocked off, and Mr. Joseph Townsend, impressed with the necessity of making some material change in the whole system of protection from lightning, is now providing the chimney with an apparatus which, it is to be desired, will fulfil its object.

This arrangement may be described in a few words. On the top of the coping stone are fixed four equidistant rods about 3 inches wide and 1 inch thick; these terminate in stars or arrow heads, and above them in the centre ascends a rod 20 feet long, and higher than the rest, terminating in a double arrow head. All these are properly connected with bands of iron, and are placed in good connection with the electric conductor and coils.

As may be readily imagined, there is some difficulty and not a little danger in raising such masses of iron to the height of 470 feet, but still more difficult and dangerous is it to construct the apparatus at the top, and fix it and bolt it together, as is required. For besides the exposure of the workman to the gases from the chimney, the atmosphere is often highly electric at that height, and freedom from sudden wind cannot be ensured. The construction is nevertheless approaching completion, and the whole of it has been done by one man, Mr. R. Hall. He is, perhaps, the only man who would undertake such work, and yet he does it with scarcely a sense of danger, and certainly with none of fear. It seems as easy to him to walk about and work on the coping stone as it is to many of us to walk about on the ground.

In concluding this sketch, which we hope may prove of some interest to manufacturers who have tall chimneys attached to their works, we would merely point out that not a little success of the working of an electric conductor depends upon the way in which it is sought to distribute the electric current over the earth. It is not sufficient simply to pass the rod down so many feet into the ground, but it should terminate preferably in a plate or sheet of iron so as to present a good surface for diffusion.

French Railway System.—Great as is the mileage of some American railways, they are all surpassed by the greatest French railway system, the Paris, Lyons, and Mediterranean. At the close of 1875 the line in operation comprised 3195 miles, and the company is constructing, or has obtained concessions for, $1228\frac{3}{4}$ miles more, which, when completed, will make the system embrace $4423\frac{3}{4}$ miles. The directors are also considering other schemes of extension.

Iron Making by Direct Process.—According to the Plattsburgh (Lake Champlain) *Commercial*, a renewed attempt to make iron directly from the ore has been recently made. Although the description does not present any manifest novelty of method any way materially differing from the processes essayed over thirty years ago in New Jersey, and elsewhere in the United States, yet the allegation of success warrants a notice, with the trust that some minor improvements of manipulation may have surmounted the former difficulties and caused the wished-for result. The Catalan forge fires, for production of loupes of charcoal iron, have held their place in the Lake Champlain country, despite all improvements or extensions of blast furnaces, and "Northern blooms" still supply the material of charcoal boiler plate and tube skelps. It is in connection with these forges that reducing chimneys are now applied.

"Adjoining two ordinary forge fires, at the rear, is a brick structure 18 feet high, 11 feet deep, and the width of both fires, including the space between them. The interior space of this brick structure is occupied by 12 air-tight retorts, each 11 feet long, 3 feet high, and 11 inches wide, and each holding a ton of ore. They are constructed of fire brick, tongued and grooved and laid in fire clay. These retorts are arranged in four tiers, three one above the other in each tier, and surrounded by a series of fire flues, also of fire brick, connected with the forge fire below and a single smoke stack above. The ore, as it comes from the separator, is mixed with an equal bulk of fine waste charcoal (*braze*) and piled upon the top of the retorts, then a slide is drawn, opening a row of holes in the top of the upper retort, and the ore and braze run in, filling it. Here it remains 12 hours, subjected to a dull red heat, very small crevices being left open to allow the escape of steam from moisture and gases. After 12 hours another slide is drawn covering a similar row of openings, connecting this with the second retort directly underneath, and the ore runs down into the next retort below, while the upper one is filled as before with fresh ore from above. In the second retort the ore remains 12 hours, subjected to a little higher temperature, when it is let down into the third one by means of another slide, which, like the other, fits tightly; here it remains 12 hours more at a bright red heat, when it is run into an oven underneath, which is tight, with the exception of an opening in front, before which a sheet of flame from the forge fire is constantly ascending in its passage to the flues

above. From this oven it is hauled out by the bloomer as he needs it, falling upon the forge fire, when it is readily reduced, forming a loop, which is then drawn as usual under the hammer. Thus the ore is subjected to a red heat for 36 hours in air-tight retorts, together with pure carbon, and it is claimed that this process results in the thorough deoxidizing of the ore, which is just the necessary preliminary chemical process desirable for making the best quality of iron at the least possible expense. It will be seen that no extra heat is required above that of the ordinary forge fire—in fact, not so much, for the ore, being already red hot when it falls upon the fire, must of course melt with less heat than if it went on cold as in the ordinary method.

"One advantage, which is no slight one, is that the consumption of coal is very materially lessened by the process, and this would abundantly pay for the extra outlay, even if the quality of the iron was not improved. The blast is reduced from $2\frac{1}{2}$ to $1\frac{3}{4}$ pounds pressure to the inch, and even with this reduction considerably more iron is made in a given time from each fire; and the fact that the fine particles of charcoal come out unchanged, after being subjected to a red heat for 36 hours, is the best possible indication of the perfection which has been attained in the construction of the furnaces, retorts, etc."

The resulting product of this process is somewhat exuberantly described in the *Commercial* with "foreshadowings of a great revolution in the process of iron manufacture by the Catalan forge process," but it seems that "every loupe of this iron is thoroughly tested, and these are afterwards assorted in three qualities—numbers one, two and three—before leaving the forge." This characteristic of direct process iron is well recollected, and it is hard on the workmen to say that one *result* of the process is to weed out the "number three men." It is stated furthermore that a test of the iron has produced horse-shoe nails "fully equal, if not superior, to those made from the finest Norway iron," which is exactly the kind of test that *raw* iron will stand best. It is, however, stated that the rough loupes are not hammered, but are rolled at once (of course, reheated) into $1\frac{1}{4}$ inch billet bars, which again are rolled into small rivet rods, such as are used in making cold rivets. So satisfactory a test does really offer a promise of a better end than previous attempts.

The *Commercial* says "the process has been patented by Mr. Edgar Peckham, the main principle involved being the heating of the ore

in air-tight retorts at different temperatures in the presence of carbon," but it is not easy to see how a patent could be either claimed or granted on the process or the principle. It has been impossible for the writer of this notice to avoid an unfavorable comment, but it will still be gratifying if, after a year's experience with the process, a definitely favorable report can be given, and our pages shall be then open for the purpose of publishing it.

Chemistry, Physics, Technology, etc.

THE FLOW OF WATER THROUGH AN OPENING IN A PIERCED PLATE.

By Robert Briggs, C. E.

(Read before the American Philosophical Society, November 3d, 1876.)

The consideration of the subject of the *vena contracta*, or section of a vein of water emerging from an orifice under certain conditions, is made a portion of the proceedings of the Philosophical Society of Glasgow, and appears in their volume X, page 145 *et seq.* Four papers are published, the first of which is an extract from a letter of William Froude, Esq., C. E., F. R. S., to Sir William Thomson, dated Cheston Cross, Torquay, 20th December, 1875. Mr. Froude is quoted[1] * * * * "One result I have tried came out well :—The discharge through an introverted cylinder [tube] with keen edge. Here, by theory, the section of the jet ought to be exactly half of the aperture. For the conservation of stream line energy obliges the velocity to be that due to the head, while the conservation of momentum requires that the pressure on the aperture (which is here the sole operative pressure setting in the ultimate direction of the velocity generated) is only sufficient to create as much momentum, say, per second as will be resident in the length delivered per second, of a column of discharge, of half

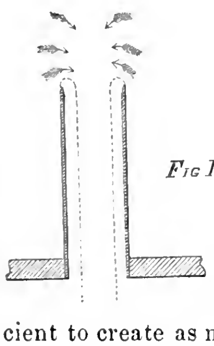


Fig 1

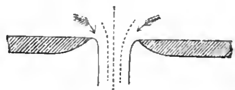
[1] The entire article is quoted ; the hiatus indicated by asterisks exists in the published Proceedings of the Glasgow Society.

the sectional area of the aperture, if its velocity is that due to the head.

"The cylinder was quite smooth outside and the edge quite keen. The area ratio came out 0·503, 0·502, etc., instead of 0·500, and the little excess was obliterated; if the head was counted, to about one-fourth the diameter below the edge, as indeed it ought to be (I won't swear to the exact figure one-fourth), because till the motion of the particles is purely parallel to the axis, there must be some acceleration to be effected in the direction of the axis, and this demands the employment of some vertical pressure. * *

"In the *vena contracta* experiment with the thin plates and open air between the plates, the fluid was welcome, if it pleased, to start tangentially to the plane of the aperture as here indicated, and as it appears to do if closely studied. So also with the introverted cylinder; although it was not possible to see what happened I have no doubt that the motion of the particles *next* the edge was vertical upwards, the curvature being only such as the pressure in the contiguous stream would satisfy. If the experiment was not adroitly initiated, the water seized the inner surfaces of the cylinder and run out in an eddied condition, filling the discharge pipe. When, however, it was properly started, the contracted column below issued with beautiful smoothness and symmetry."

FIG 2



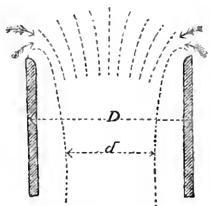


FIG 3

The second paper on the subject is an extract from a letter of Sir Isaac Newton to Professor Cotes, March 24th, 1710-11; from the "*Correspondence of Sir Isaac Newton and Professor Cotes, including Letters from other eminent men*," published in 1850, by Mr. J. Eddlestone, Fellow of Trinity College, Cambridge, from the originals in the Library of Trinity College. This letter possesses much value as showing Newton's experiment and discussions of the form of the *vena contracta*, and will be found interesting to examine in the proceedings of the Glasgow Society by those who have not ready access to the primary publication. Newton found the *vena contracta* from an aperture in the *side* of a vessel of thin sheet tin plate, five-eighths of an inch in diameter, to have, at the distance of one-half an inch from the hole, a diameter of $\frac{21}{40}$ of an inch; which was a reduction of diameter of $\frac{21}{25}$, and of areas of cross-section of 0·7058.

A foot-note to this letter of Newton by Mr. Eddlestone says, that "*Sectio vena contracta*" was a term used by Jurin, Philosoph. Trans., Sept.—Octo., 1722, p. 185; and that Dan. Bernouilli uses the same term, Hydrodynam., p. 65. Jurin also uses "*vena contracta*"; in all these cases the words denote the reduced section only, while subsequent usage generally applies them to the stream itself as a body, between the orifice and the point of reduced section.

The third paper is a discussion of the *vena contracta* by Professor James Thomson, LL. D., C. E., University of Glasgow, and is a mathematical discussion with six illustrations, intended to demonstrate under certain conditions, as for instance the supposed absence of fluid friction or viscosity, and a supposed great magnitude of vessel and depth of water compared with the dimensions of the orifice, that the jet of water issuing from an orifice in a thin plate, from a conical adjutage either protruding or re-entrant, has a section, where the stream flows out in sensibly parallel lines, of *more* than half the area of the orifice, and that this condition only ceases for a re-entrant nozzle, in the form of a parallel tube as treated of in Mr. Froude's paper. The conclusions of Professor Thomson do not seem to the writer as warranted by the conditions to which he limits his proposition. The value of the assumed force which he denotes by P is by no means satisfactorily exhibited. As the purpose of this paper is to discuss other points, further notice of Professor Thomson's article may be omitted, only it will be assumed that the reader of this refers to the Glasgow Society's proceedings to see for himself what is set forth by the Professor.

The fourth paper is an abstract of remarks by R. D. Napier, Esq., who gave some consideration of this subject, which was published in 1866, in a pamphlet "*On the Velocity of Steam, etc.*," in which he made the general assertion, with some qualifications, that the area of the true theoretical *vena contracta* is half that of the orifice. He says, "I have proved in the pamphlet referred to, that the pressure in the plane of the orifice is nearly half the pressure due to the head, and that from thence to the *vena contracta* [the words are here used in the sense of the section of least area] it gradually diminishes to zero. The diminishing pressure causes increasing velocity, and is thus the direct cause of the *vena contracta*. * * * "About three-eighths of the ultimate velocity and five-eighths of the *vis visa* are imparted to the water outside of the plane of the orifice, and it is absurd to attribute these effects either to what I

may call the converging momentum being transferred from one side of the orifice to the other, or to the converging particles preventing the free egress of the stream through the orifice, which are the only views hitherto offered to explain the cause of the *vena contracta*."

This question of the *vena contracta* is a very pretty one in physics, and deserves a more complete and general discussion than it receives in the pages of the Glasgow Society. It should be recognized however, that it does not admit of the simplicity of investigation, either mathematically or experimentally, which the papers of Mr. Froude and Professor Thomson assume. It is impossible to divest the consideration from the fluid friction against the contiguous sides, surfaces, or the edges of the aperture, nor from the fluid friction of the liquid within itself which constitutes *viscosity;* nor yet further, from the frictional resistance to discharge into another medium (the atmosphere in this case); while the absolute strength of water is brought into action in the emerging column to the extent of pressure of the atmosphere. Values for these various elements can be accepted, and the mathematical investigation proceeding from them, would enable a thorough solution of the problem, in place of the extremely partial one essayed in the proceedings of the Glasgow Philo. Soc. Even the effect of dimension of vessel or volume or water with relation to the aperture might be made a part of the investigation and appear in the result.

In such an attempt to find a general solution of the theorem it would at once become evident, that there are two normal forms for the *vena contracta*, viz.: That, when the stream emerges *downwards* from an opening through horizontal edges, and that, where it emerges *upwards* through an opening of the same character. The first of these gives a pencil, whose shape for its longitudinal section at its upper end, or origin, will be controlled by the nature of the aperture, and by the effect of the initial directions of the particles of the effluent liquid (the theoretical *vena contracta, under pressure, but devoid of gravity*); modified by the effect of gravity, which would give to any descending pencil of a fluid, the motion of whose particles shall be established in approximately parallel lines, a hyperboloid contour. The second of these will give a sheaf, whose shape at the point of efflux, will be determined by the same laws; while it would now be modified at this point, by the *load* of the emerging fountain, and at the same time the form of the stream above (in this case attaining on some plane an absolutely contracted section) would be that of a hyperboloid

sheaf, with both *external* and *internal* lines of definition. If it be supposed in this second instance that the plane of efflux (of the orifice) is slightly deviated from the horizontal, so that the emerging stream is made to take a line out of the perpendicular one, the sheaf form would be disturbed; and at some quite small angle of deviation, a trajectory curve would take its place.

The general course of the stream would then have a modified parabolic curvature—a trajectory curve, which has been frequently discussed—but the exact contour of the pencil is still an open question. It is certain that when passing the point of greatest elevation, it would have, from its retarded motion, its greatest cross-section, and that this cross-section would be a flat oval of peculiar form; and it is probable that beyond this section, on the descending stream, it would become nodal, for the same reasons that a stream emerging from any orifice except a circular one becomes nodal.[1] In short the complete solution of the problem not only admits and assumes values for all the physical conditions, but it will embrace all directions of efflux from 0° to 180°, where 0° may be taken as the perpendicular direction, either upwards or downwards.

It is possible, for the purpose of illustration, to give some consideration of the *vena contracta* upon hypotheses similar to those of Prof. Thomson, and if other conditions are assumed at the same time, an *appreciation* of the phenomenon can be had. In truth, the view it is proposed to offer may go further than a mere appreciation, and may be made the basis for support of the other fundamental controlling conditions, and indicate the true line of procedure for mathematical investigation. Let us suppose, with Professor Thomson, that the effect of fluid friction, or viscosity, is neglected; that the magnitude of the vessel and the depth of liquid, is so large in relation to the dimensions of the orifice, that no appreciable velocity is imparted to the mass of liquid by the discharge; that the jet is one issuing downwards (so as to have the cross-section under absolutely uniform pressure); that the orifice is a circular hole in a thin plate—the flat bottom plate of the vessel—and that the effect of gravity on the stream after emergence be neglected, as well as the atmospheric resistance and the acceleration due to the column of discharge, in the production of a vacuum upon the sectional area; and the following sketch (Fig. 4)

[1] See article by Weisbach, "Ausfluss," in the "Allgemeine Maschinen Encyclopädie."

gives a general ideal view of the *vena contracta* under these suppositions.

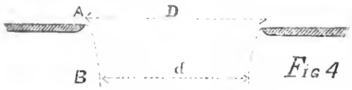


Fig 4

Weisbach[1] has observed that the actual diameter $= d$ of the vein of emergence from a thin plate, is about $0{\cdot}8\ D$; at the point B, which will be found from one-fourth to one-half the diameter ($= D$) from the plate; and this is accompanied with an efflux, as measured by the quantity of water discharged, of $= 0{\cdot}97\ v$, where $v =$ the velocity of flow $= \sqrt{2\,g\,h}$. Now it is an obvious conclusion that at any point on the surface of the *vena contracta* between A, the edges of the plate, and B, the point of minimum section, a particle of water must be in such equilibrium of pressure as to establish its direction of flow, or in other words its curved path; when it becomes apparent that some momentum must have been imparted to such a particle, to induce it to follow in its line of trajectory, instead of following the direction due to gravity, or to the application of the pressure normal to the head, or column of water above it. An attachment to the orifice can be constructed which will exhibit this phenomenon, or rather provide for its occurrence as a matter of necessity, as follows: Let there be an opening in a thin plate as before (Fig. 5), and let this opening be *guarded* or protected by a disc (Z) of the same diameter, $= D$, let this disc be placed so that its edges ($C\,C$) shall be one-eighth the diameter $= \frac{1}{8}\ D\ (C\,A)$ removed from the hole. On these suppositions, if the diameter of the section of least area, $= d$, be taken at $0{\cdot}707\ D$, then the area of the peripheral opening (at $C\,A$) will be equal to the area on the plane of (B). The line of effluent stream ($A\,B$) may be imagined to be a quadrant of a circle, which will then have, of course, a radius, $= 0{\cdot}147\ D$. Now let the face of the disc Z be made a conoid, so that the areas of the surfaces of the conical frustra *a b c d e* shall be equal, or in other words, so that all the sections normal to the curve $A\,B$ shall be equal.

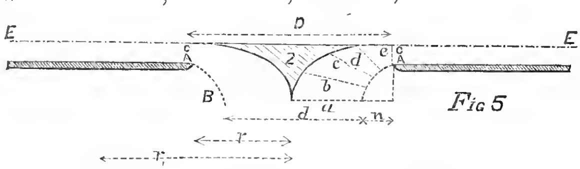


Fig 5

[The co-ordinates for this curve of the face of the conoid Z, in terms of x and y, where x is supposed to have its origin at point of the prolongation of the line $C\,A$ on the line B, are given by the equation :

[1] Weisbach's Mechanics.

$$y = \frac{\sqrt{[r^2 + n^2 \pm \sqrt{(r^2 + n^2)^2 - 4\,n^2 x\,(2\,r - x)}] - 4\,(r - x)^2\,(r + x)^2}}{2\,(2\,r - x)}.$$

In this equation $r =$ the radius of the opening commencing at the origin of x, and $n =$ the radius of the quadrant or corner commencing at the same point.

The assumption of the quadrant of a circle for the path of the effluent particle from A to B, has been made in order to give a simple equation for, and ready comprehension of, the nature of the sections of the stream normal to its face on $A\,B$ where, by equalities of areas, uniform velocities would subsist; but the real curvature $(A\,B)$ is obviously parabolic, and the plane of B is infinitely distant from (below) the plane of A. Observation has shown, that at about one-fourth D below the plane of A the least section of *vena contracta* is apparently reached, and that below this plane of section, the pencil of descending current has its sides with only so much divergence from parallelism, as is due, almost entirely, to the acceleration of the falling stream. An elliptical quadrant which shall approximate to the true parabolic curve can be readily substituted by construction (or calculation) for the quadrant of a circle, in the equation above quoted, and the new values for y, will give loci for the curve of the face of the conoid Z to correspond to the substitution. The value of the radius of the minor axis on the line B as determined by observation, may be taken as that of (n) in the equation. By this method a very close approximation towards the true form may be attained.]

It will then result that the efflux from the peripheral opening $C\,A$ inwards, having any given velocity, will, in every part of the current, until the least section of the *vena contràcta* on the plane B is reached have a uniform and constant rate of speed; neither acceleration, nor transformation of head into velocity, will have occurred in the change of direction. If the consideration of the fluid friction, etc., be not taken into the question, and the velocity of efflux at $C\,A$ is that due to the head, that at B is established and maintained; whence any liquid particle on the surface $A\,B$ must be in equilibrium of pressure, both from head or momentum in direction of its flow, *in which direction the entire head is transformed into velocity.* The plate, or plane surface of D, may be imagined to extend indefinitely in the directions, $E\,E$, in which case the velocity of flow of liquid, interposed between the plate E and the bottom A, will decrease as the radial distances from the edge of the aperture; in inverse ratios of the radius r to any

new radii $r_{/}\ r_{//}\ r_{///}$: while the height, of liquid column corresponding to the several velocities, $= V$ at r, $V_{//}$ at $r_{/}$, will vary as $\left(\frac{r}{r}\right)^2 : \left(\frac{r}{r_{/}}\right)^2 : \left(\frac{r}{r_{//}}\right)^2$ etc. The pressure or total height is supposed to have been completely transformed into velocity, $= V$, at the peripheral opening $C\,A$, and the stream or sheet of fluid would exert no transverse pressure at $C\,A$, either upwards or downwards; while the transverse fluid pressure on the supposed plate or the bottom of the vessel would vary as $\left(\frac{r}{r}\right)^2$ (at $C\,A$) to $\left[\left(\frac{r}{r}\right)^2 - \left(\frac{r}{r_n}\right)^2\right]$; r_n being any assumed radial distance from the centre of the opening. Thus if the radius r be taken as one-half inch, and that of r_n as five inches (or ten times r), the velocity of flow towards the aperture at r_{10} would be only one-tenth of that at r; the head required to produce the velocity at r_{10} would only be one-one-hundredth of that corresponding to the velocity at r; and the pressure of the head remaining on the plate or bottom at r_{10}, would be ninety-nine–one-hundredths of the total head.

These two pressures on the plate and the bottom would be equal and opposite pressures, and if the plate were removed, the unbalanced pressure on the bottom would represent the force P, to which Professor Thomson gives an undefined value. Its total is, of course, the sum of the head upon the area of half the opening, and continuing the supposition of removal of the plate, it is encountered and balanced by the *momentum of the descending mass*, so that the bottom would now be in equilibrium of pressure, and the force P, as an unbalanced one, would disappear.

Returning to the examination of the proposition as shown in Fig. 5: the static resistance of the under surface of the conoid Z in a vertical direction against the flow of water in its radial movement towards the centre of the orifice, and while following the path of the under surface of the conoid, is represented in total by the divergence at right angles of the entire effluent stream; $=$ to $\frac{1}{2}\,D$ of superfice, under the head which has produced the efflux. The reaction of the flow of liquid downwards is also equal to another statical resistance of the same value, and in the same direction; and as the total pressure on the conoid Z from above, is its entire upper surface, under the head of liquid above it; the one pressure above balances the two pressures below, and the conoid itself is in equilibrium.

If it is now assumed that there exists no frictional adhesion of the liquid to the surfaces of the supposed plate, and of the bottom of the vessel, and the vessel is of indefinite extent, so that the velocity of entry at $E\,E$ is reduced to an inappreciable rate of flow, then the condition of the formation of a perfect *vena contracta* will have been exhibited. The removal of the guide plate $E\,E$, and the removal of the bottom of the vessel, and substitution of a re-entrant tube, would replace the supposed frictionless surfaces by liquid mass, which if it is still continued to be supposed devoid of *viscosity*, would enter the peripheral surface $C\,A$ with the same force, and in the same direction, and would still preserve the same perfect *vena contracta.* The removal of the conoid Z would provide a fluid conoid of the same shape, *or a distribution of internal strains* productive of the same resistance, and (still assuming the perfect liquid) the same perfect *vena contracta* would follow. If, however, there is admitted to exist a certain adhesion to the bottom of the vessel, or to the surface or edges $A\,A$ so that the velocity of a particle on $A\,B$ is less than that fully due to the head; the surface (d) would then become larger than $\frac{1}{2}\,D$, the dimension $C\,A$ would be properly increased to give the corresponding area of efflux, and the conoid Z would also have such a contour as would permit the uniformity of flow of each and every particle of the liquid at unchanged velocity, in any section of the *vena contracta* transverse to the direction of the flow. This increase of dimension of the cross-section d, and the effect of the descending pencil in accelerating the flow through it, can be taken as sufficient to account for Weisbach's observed value of $= 0{\cdot}8\,D$, and position of least section at $= \frac{1}{4}\,D$, as has been before quoted.

It must not be taken for granted that the writer is arguing that the conoid Z actually exists in the water, but it is here assumed for the purpose of showing that all the phenomena of the *vena contracta* are consistent with the supposition. Mr. Froude's "*tangential*" direction for the fluid in Fig. 2, which he says appears if closely studied, is a portion of the proposition, and this discussion exhibits "the imparting of velocity and *vis viva* outside of the plane of the orifice," as alluded to by Mr. Napier.

There is one other point worthy of notice in this radial flow of currents towards an orifice, and the radial direction at the edges of the opening. With or without the assumed central, neutral conoid, this flow is in exceedingly unstable equilibrium, especially when in contact

with a bottom plate (the friction or adhesion to which retards the flow), the radial direction may be diverted to a small extent, so that the particle of water where it curves at the point A, or at any other point on the line CA may possess absolute momentum out of the line towards the central axis of the pencil.

The radius of the openings calls for a very slight deviation of entering horizontal current, when its dimension is compared to the area from which this current is derived; and there is really but the slightest cause for the currents to direct themselves to the exact centre of the orifice. In point of fact the permanency of the *vena contracta* of downward discharge is derived in great degree from the pressure of the atmosphere, which is brought into action, by the descending pencil below it. The effect of a tangential afflux at the peripheral circle CA is to give a rotation to pencil, which at once accelerates, to some limit of discharge, and obliterates the *vena contracta.* The motion of the particles will yet remain limited *in any direction* by the head, but as the stream emerges with a rotary motion, the path of any particle becomes a spiral one, and the whole pencil advances, or is discharged, at a slower rate than is due to the particle velocity. In the case of the re-entrant tube, where the pencil is divested from the effect of gravity, by exhaustion of the air by the effluent stream passing from the tube, it is very difficult to get a *vena contracta*, as Mr. Froude testifies. This action of the tangential afflux is not confined to the emerging stream, but shows itself in the vessel as well, where a whirl is established which involves the entire mass of water enclosed. In the case where the bottom of the vessel has a funnel shape, this whirl sets up with great vehemence, and the centrifugal force of the established current may be sufficient, under favorable circumstances of form, head and dimension of vessel, to displace the entire central portion of the liquid, and the pencil of emergence will become a tube, whose core will be filled by an induced current of air. These phenomena of efflux are only noticed to embrace in my remarks some of the influences which effect the *vena contracta* where the conditions of formation are varied by adjutages, and to make it evident that neither the study of phenomenal nor the mathematical considerations involved, have been exhausted in the papers of the Glasgow Philosophical Society; while the present article does not pretend to do more than to indicate the direction in which inquiry should be pursued.

ON THE GROWTH OF THE

ALKALI AND BLEACHING POWDER MANUFACTURE OF THE DISTRICT OF GLASGOW.

By JAS. MACTEAR.

Paper offered to the British Association for the advancement of sciences. Read before the Chemical Section, September 12th, 1876.

[Continued from Vol. ciii, page 63.]

PART. IV.—ALKALI.

The production of alkali has been one of the Glasgow chemical industries since at least 1798.

It seems to have been made at first by furnacing kelp with charcoal and a little quicklime.

A method in use for the production of an impure alkali for soap boilers is described as follows in a note-book dated 1800 :—

" *To make the Hepar of Soda or Potass from the Sulphates.*"

" It is necessary to dry these salts in a reverberatory furnace, then " mix them with their weight of fir sawdust, and fuse them in a rever- " beratory furnace; when the surface becomes calm, the operation is " complete—let the sulphure run out. If it is a sulphure of potass, " break it up with a hammer, dissolve in water, evaporate it, and when " the salt begins to form, put in sawdust till it is thick.

" Then put it into the calcining furnace, roast it for an hour, two- " thirds of the sulphate will be decomposed, separate the undecom- " posed part by solution.

" If you operate on the sulphate of soda, after the first sulphure is " produced, add more sawdust, melt a second time to a sulphure, then " operate as with the potass."

The use of the still liquors from the chlorine manufacture early attracted attention.

These consisted chiefly of sulphates of soda and manganese, and were at first worked up into Glauber's salt, and the manganese seems to have been recovered to some slight extent.

In the year 1800 Lord Dundas had a work for the manufacture of mineral alkali in operation at Dalmuir.

The works were of considerable size for that period, as the following table will show, being a statement of the working tor years 1801 to 1804 :—

VIEW OF MINERAL ALKALI WORKS.

YRS.	ALKALI SOLD.				PRICE PER TON.	BLACK ASHES SOLD.		PRICE PER TON.	BARILLA SOLD.				PRICE PER TON.	MURIATE OF POTASS SOLD		PRICE PER TON.
	T.	C.	Q.	LB.		T.	C.		T.	C.	Q.	LB.		T.	C.	
1801	25	12	2	24	£49·5	112	15	£10·	5	0	3	23	£15·	54	10	£13·
1802	62	11	0	21	47·9	31	5	12·2	14	6	0	0	20·2	122	0	13·24
1803	46	16	1	2	41·2	......		......	23	17	1	25	20·	121	10	13·
1804	128	16	2	6	37·	......		......	21	6	3	0	20·9	90	0	6·5
	263	16	2	5	42·	144	0	10·56	64	11	0	20	20·23	388	0	10·56

From the fact that soap lyes and the salts obtained from them were purchased in large quantity from the soap makers, it is probable that the process was substantially the same as that described as follows, in November, 1806 :—

"At Dalmuir they prepared from soap lyes got from Paisley and "elsewhere, 150 tons salts, and from these 120 tons crystals of soda "and 21 tons muriate of potass.

"The manufacture employed 15 workmen, and consumed 1200 tons "of coal at 10*s.* per ton, delivered at the works, and used 200 barrels "potass at 10*s.*

"Sal-e-nixon (sulphate of potass) and sulphur ashes (chiefly sul- "phate of potass), from nitre used in the vitriol manufacture.

"When potass is used, it is added to the mother liquors of the "first crystallization of soda, never put into the furnace with the soap "salts.

"When sal-e-nixon or sulphur ashes are used, the first is put into "the furnace with the salts, sawdust, and a little quicklime; the "second is first lixiviated.

"Their furnace yields 12 cwt. of flux per charge, and requires six "hours to flux it. They do two charges in 12 hours, but do not work "at night, it being found a preservation of the furnace to allow it to "cool during the night.

"The furnace is shut up when the charge is put in, and is never "stirred during the operation.

"Soda and muriate of potass are crystallized out alternately.

"The muriate of potass is never raked out of the hot solution of "the salts. The carbonate of soda is found to fall with the muriate "when the evaporation is continued until the salts begin to form.

"They do not know whether the decomposition of the muriate of "soda with the sulphate takes place in the furnace or in the subse-"quent process of evaporation.

"The mother liquors are heated with sawdust in order to make "them crystallize, that is, to carbonate them.

"The soda is seldom ever crystallized twice, particular attention "being paid to having the solution pure.

"The liquors are sometimes filtered.

"The soapers' lyes are evaporated in iron vessels, say circular ves-"sels of the usual form, in one piece, and yielding 8 cwt. salts per "day. They contain about 500 gallons each.

"The lead coolers are 9 ft. long by 4½ ft. broad, and 10 in. deep.

"The lead boilers are nearly of the same dimensions, but 15 in. "deep.

"They say they have found a substitute for potash in decomposing "the muriate of soda, which works equally well and does not cost "20*s*. per ton.

"The crystals are seldom ever free from muriate of potass, even "when the crystallization is pretty perfect in form.

"The muriate of potass, on the other hand, is seldom ever free "from alkali.

"When the potass is redundant in the liquors, they will not crys-"tallize.

"After the muriate of potass is crystallized, the mother liquor is "carbonated, and soda crystallized from it.

" *Charges on One ton of Soda.*

"1·25 tons soap salts, at 6*l*., 10*s*.,	£8	2	6
"0·15 " potass, at 60*l*.,	9	0	0
"4·00 " coals, at 10*s*.,	2	0	0
"40 bags sawdust, at 4*d*.,	0	13	4
"Wages,	5	0	0
"Incidents,	1	0	0
"Tear and wear,	3	0	0
"Interest,	2	10	0
	"£31	5	10"

In all,	£31	5	10
By 3 cwt. muriate of potass, at 13*s*.,	1	19	0
Net cost of 1 ton of crystals of soda,	£29	6	10

Selling price, about £60.

The yearly statement shows the make to have been 120 tons, and the cost 32*l.* per ton.

By another method in use about the same period, a mixture of 10 cwt. of soapers' salts, 6 cwt. of sawdust, and 3 cwt. of lime, was heated for 6 hours in a furnace until fluxed; it was then run off, and when cold, broken into small pieces and lixiviated in large vessels holding as much as 10 tons at a time, on a filter bottom of gravel and sand placed on coarse canvas. This filter lasted two to three months.

The liquor from this black ash deposited a considerable quantity of muriate of potass.

The remaining liquor was evaporated slowly without boiling till a pellicle formed, and then run off to crystallize.

To the mother liquors, from this crystallization, 3 cwt. or so of potash, in solution (according to quality of liquor), is added, the liquid again concentrated and crystallized, this being the third crop of muriate of potash crystals.

The mother liquor from this was called barilla liquor; it was boiled down to dryness, the salts mixed with their own weight of sawdust, and carefully roasted till the sawdust was consumed, never being allowed to flux.

Another method of carbonating was to make the salts red hot, and then mix them as quickly as possible with powdered charcoal.

This carbonated alkali was then lixiviated with cold water, evaporated till a pellicle formed, and after settling for about 12 hours, run into coolers to crystallize.

This soda was re-crystallized.

"In preparing barilla salts for bleachers" (this was actually what is now called soda ash), "the color may be regulated by the use of "nitre—if a white is desired, a greater quantity; if a blue, a lesser "will suffice.

"A note of the production of soda from kelp shows that from

"100·00 kelp,
" 2·72 charcoal,
" 7·29 potass (crude),
"200·00 coals,

"there should be obtained

"74·3 soda crystals,
"28·4 muriate of potass,
"33·0 sulphate of potass."

The methods which were adopted at the St. Rollox Works were very various as fresh light was thrown on the science of chemistry.

Almost immediately after the commencement of bleaching powder manufacture, the waste products of the stills were utilized for the production of alkali for soap making.

These residues, consisting chiefly of sulphate of soda and manganese, with varying quantities of common salt and sulphuric acid in the free state, were in the first case used in the manufacture of Glauber's salts; this was followed by a method of making sal ammoniac from urine collected in Glasgow in casks.[1]

This process was found unsuitable, probably from the difficulty of obtaining ammonia in sufficient quantity, and was soon displaced (in 1803) by a process, or rather a sequence of processes, which, with slight variations, continued in use for many years, until the introduction of the complete Leblanc system of alkali making.

This was the production of a crude alkali or black ash for use in soap making instead of kelp, then usually employed.

The earliest details which I have been able to find show that the still residuums were run into wooden tubs, where they were mixed with ground coal or sawdust till in a thick pasty state; this mass was then transferred to a reverberatory furnace and melted. When the decomposition had ceased, it was run out, and when cold, broken up and lixiviated with caustic lime, and the caustic lyes thus formed were used in the saponification of the fatty matters.

This was followed by the method of mixing the liquor obtained by lixiviating the above black ash with sawdust, and again furnacing, when a barilla was obtained worth at that time about 28*l.* per ton.

Cost of One Ton Barilla from Residuum.

6 cwt. salts, at 5*s.*, ...	£1	10	0
5 " lime, at 1*s.*, ...	0	5	0
40 " coal, at 7*s.* 6*d.*, ...	0	15	0
Labor, ...	0	6	0
Tear and wear, ...	0	2	0
Yielding one ton barilla, costing . .	£2	18	0

And containing 3 to 10 per cent. alkali, worth then about 10*l.* per ton.

The soap lyes, after having become spent, were boiled down to salts, and barilla again made from them, much on the system already described as in use at Dalmuir.

[1] The obtaining of ammonia from urine has been tried at various times in Glasgow, and at present Mr. G. Chapman works a process which is believed to be very successful.

Cost of One Ton Barilla from Soapers' Salts:

	£	s.	d.
14 cwt. of soapers' salts, at 5*s*.,	£3	10	0
3 " lime, at 1*s*.,	0	3	0
20 " coal, at 7*s*. 6*d*.,	0	7	6
Labor,	0	4	0
Tear and wear,	0	1	4
	£4	5	10
By 10 cwt. of muriate of potash, at 5*s*.,	2	10	0
One ton of barilla of 7 per cent. alkali, costing	£1	15	10

At first the muriate of potash was employed in the stills instead of common salt, but this was soon given up, and the muriate of potash was sold, chiefly to the alum makers of the district.

The manufacture of vitriol gave as a by-product a considerable quantity of "sulphur ash" residues, consisting of sulphate of potash, mixed with a little unburnt sulphur. This was used along with soapers' salts, and gave a larger yield of muriate of potash.

The mixture employed seems to have been at this time—

280	lbs.	soapers' salts.
112	"	sulphur ashes.
84	"	lime.
112	"	coal.
588	"	in all.

Yielding 364 lbs. black ash, containing 10·5 per cent. alkali, and 25 per cent. insoluble.

In 1806 a trial was made of the mother liquors from the alum works as a source of potash; the black ash made from a mixture of this liquor and soapers' salts gave only about 6 per cent. alkali, and from this and other causes its use was soon abandoned.

"A statement of the products obtained at this time from 100 parts
"of salt is subjoined:—

"100 parts salt,
" 83 " oil of vitriol,
" 56 " manganese,

"produce bleaching powder. The residue from above, with

"150 parts American potash of 81 per cent.,

"produces

"265 parts soda crystals.
"160 " sulphate of potash.
" 50 " of manganese recovered.

"It will therefore produce as much soap as 16 cwt. of kelp, even "reckoning kelp as containing above 3 per cent. of real soda, worth "10*s*. per cwt."

Methods more or less of this nature continued to be used until about 1816, when a good deal of correspondence with the French manufacturers, Chaptal & D'Arcet, took place, relative to the Leblanc system, which was finally adopted in 1818.

The following extract from the correspondence is of considerable interest, under date of July, 1816. Messrs. C. & D'A. say, in reference to their manufacture of soda:—

"They produced 44,000 lbs. per day of crude soda (black ash), "containing 20 to 21 per cent. alkali, which they sell at 20 francs per "quintal (equal to 16*s*. 8*d*.).

"It is produced from common salt obtained from the spontaneous "evaporation of the sea water at Marseilles, and costs about 9*d*. to "10*d*. per quintal. It is decomposed by sulphuric acid in the pro-"portion of 83 acid to 100 salt.

"In purifying their crude soda, and crystallizing, they always "experience a loss of 25 per cent. of the alkali, indicated by the acid "test in the crude soda."

These gentlemen utilized to some extent the muriatic acid evolved, by producing gelatine from bones, for the manufacture of soup, of which M. D'Arcet says he had made 1,300,000 portions of a quart each.

In 1818 these gentlemen had the intention to "establish works in "Liege and in London, for making soda, nitric acid, marine acid, "gelatine, etc."

In this year a process was at work at Port-Dundas for preparing a black ash for soap-making purposes, and this is the first record of the use of carbonate of lime (previously caustic lime seems to have been always used).

The mixture used was:—

10	parts	soapers' salts.
$2\frac{1}{2}$	"	poor kelp.
$2\frac{1}{2}$	"	chalk.
5	"	sawdust.

This was fluxed for 6 hours, and gave a black ash testing 6 to 7 per cent. alkali.

In the end of this year, French soda was imported into London. It was in the form of black ash, and of three qualities.

No 1,	containing	13	per cent.	alkali,	sold at	£30 per ton.
" 2,	"	12	"	"	"	26 "
" 3,	"	11	"	"	"	25 "

It was manufactured at Marseilles by the Leblanc process, which had been fully established there for some years. Three qualities of soda were made for sale.

1. Crude soda (now called black ash).
2. Crystals obtained by the lixiviation of the crude soda.
3. Calcined residues from the "bitter water" (now called soda ash).

All these qualities had certainly been produced since the year 1807, works being in operation at Marseilles, Chauny, Rouen, Lille, Amiens, and elsewhere.

The first sale of soda made at St. Rollox on the Leblanc system, took place in the end of 1818. It was sold at 42*l.* per ton. Carbonate of soda, or soda ash, had been made for some months previously, but was apparently all consumed in the manufacture of soap.

The use of soapers' salts was still continued, and black ash was made for sale from the following mixture:—

	1 cwt.	Irish kelp.
	$1\frac{1}{2}$ "	soap salts.
	1 "	sulphur ashes.
	$1\frac{1}{4}$ "	chalk.
	$1\frac{1}{2}$ "	coals.
In all,	$6\frac{1}{4}$ cwt.	

Yielding 3 cwt., 2 qrs., 14 lbs. black ash, containing 14 per cent. alkali.

In the following years soda crystals were sold in constantly increasing quantities.

Table of Prices realized.

Year.	Price per Ton.	Year.	Price per Ton.
1818, . .	£42 0 0	1844, . .	£6 0 0
1819, . .	41 0 0	1849, . .	5 10 0
1820, . .	40 0 0	1854, . .	4 10 0
1824, . .	27 0 0	1859, . .	6 0 0
1829, . .	15 0 0	1864, . .	4 15 0
1834, . .	12 0 0	1869, . .	4 5 0
1839, . .	11 0 0	1874, . .	5 10 0

The quantity made has rapidly increased from about 100 tons in 1818, to 1400 tons in 1829, and is now nearly 14,000 tons per annum.

Carbonate of potash was made in considerable quantities from about 1820.

It was produced from the sulphate of potash (obtained as a by-product in the manufacture of sulphuric acid) by the Leblanc system. The price in 1820 was 15*l.* per ton. On the introduction of nitrate of soda as a substitute for nitrate of potash, this manufacture was given up at St. Rollox; but it has revived again in the district within the last few years, considerable quantities being now manufactured, chiefly for their own use, by the bichromate and prussiate of potash manufacturers.

Soda ash, so-called, was first sold from these works in 1833, when it rapidly took the place of black ash, previously sold. In 1833 only 19 tons of soda ash were sold at a price of 22*l.* per ton; in 1865 the quantity had increased to 12,500 tons, sold at 9*l.* per ton.

The sulphate of soda required for the manufacture on the Leblanc system was at first prepared at these works in iron cylinders (such as are yet usually employed in the manufacture of nitric acid), and the muriatic acid evolved was condensed in upright earthenware condensers.

In 1822, pots of some form were introduced, the charge of salt weighing $4\frac{1}{2}$ cwt., and yielding 560 lbs. muriatic acid of 40°.

Various improvements were introduced from time to time, amongst others, Gamble's improved furnace for salt-cake making; Gossage's condensing towers; the circulating system of vats for lixiviating black ash, first adopted at these works, and introduced by Mr. C. T. Dunlop.

The revolving black ash furnace of Elliott & Russell was tried at St. Rollox soon after its invention, but failed at that time to give satisfaction, the furnace at that time being too small and imperfect to compete with hand labor at the low rates then paid.

It was much improved by Messrs. Stevenson & Williamson, of the Jarrow Works, both in construction and in the method of working it, and became in their hands quite a success.

This form of furnace was again introduced at the St. Rollox Works, where there are now three furnaces.

These are worked on a system, patented by the writer, which has been eminently successful. It has increased the producing power of the furnaces over 50 per cent., with a large saving of raw material, and a corresponding diminution in the quantity of waste produced.

The amount of alkali usually lost in the waste being proportionately reduced.

This system is now employed in a number of the largest alkali works in England, and it is expected will shortly be at work in France.

The form of the furnace has at the same time been much improved; and while the first furnace erected at Jarrow was capable of working somewhere about eight tons sulphate of soda per 24 hours, the most recent of those erected at St. Rollox decomposes 50 tons in the same time.

The three revolving furnaces easily decompose 720 tons sulphate of soda per week of six days.

The most recent improvement introduced is a mechanical furnace for calcining or carbonating the soda ash. This has only been at work for a short time, but promises to be quite as successful as the black ash furnaces have been.

Other works in Glasgow and the district have been erected at various times for the manufacture of alkali, of which there are at present existing as alkali works, so far as I can ascertain, only four, viz.:—

Messrs. R. & J. Garroway, Glasgow.
" Orr & Brown, Irvine.
" W. Henderson & Co., Irvine.
" Arnott Bros. & Co., Kirkintilloch.

Part V.—Caustic Soda.

The production of caustic soda was begun at the St. Rollox Works as far back as 1844, by means of a process introduced by a Mr. Weisenfeldt. It was made from the red liquors fused with nitre, and was perfectly white; but there being little or no demand for the article, the manufacture was for the time given up.

The manufacture was again resumed about fifteen months ago, and the various qualities and strengths of—

Cream or unfused, . . .	60 per cent.
White or fused, . . .	60 "
Do., . . .	70 to 72 "
White, double refined, .	74 to 76 "

are now manufactured.

Part VI.—Manganese Recovery.

The recovery or regeneration of the manganese contained in the residuum from the bleaching powder manufacture was the object of constant investigation. Various methods were tried with but little success, amongst others, those of Binks and of Gossage.

The process still worked at St. Rollox is one invented by Mr. C. T. Dunlop in 1855, in which the acid still liquors are first neutralized with chalk, and the settled liquor is decomposed under pressure by milk of chalk; the carbonate of manganese thus obtained is washed, dried, and submitted to a heat of about 600° Fahr. for 48 hours, when it gives a black oxide of manganese of high strength.

A description of the process is given in most modern works on technical chemistry.

This method of recovering manganese is not in use at any other chemical works, the method now universally adopted being that invented by Mr. W. Weldon, which has been adopted by Messrs. C. Tennant & Co., at their works at Hebburn, near Newcastle-on-Tyne, in preference to extending the Dunlop process to that establishment.

Mr. Weldon's process is used, I understand, by all the other makers of bleaching powder in Scotland.

Part VII.—Sulphur Recovery.

The position of the St. Rollox Works, and the enormous deposits of alkali waste which have accumulated during the long period of their existence as alkali works, caused the question of the recovery of the sulphur from the waste, or from the drainage liquor from the heaps, to become a very serious one. These drainage liquors at one time flowed into a stream called the Pinkston Burn, and from thence found their way into the Kelvin, and ultimately into the Clyde.

Many processes were devised and tried to keep down this flow of drainage, and a very large sum was spent in driving a series of galleries deep down in the rock under the waste heaps, to try, if possible, and intercept a number of springs of water which, rising under the heaps, dissolved and carried away the soluble sulphur compounds of the waste.

It was not till the beginning of 1868 that a process was at work in a way that might be called successful. It was one adapted by Mr. Ludwig Mond, and consisted in oxidizing the fresh exhausted waste while still in the vats by blowing air through, and then using the liquor draining from the heaps instead of water to dissolve out the sulphur compounds.

This process was worked for some years, but had two defects. There was a considerable amount of sulphuretted hydrogen given off in the process of oxidizing, and it was not found possible to utilize

by this process all the drainage, which was produced in large quantity.

It was superseded in 1871 by a process invented by the writer, which has been very successful, reducing the nuisance arising from these liquors to a very small amount. There is now absolutely no drainage flowing into the Kelvin; and only in such exceptional cases as that of excessive rainfall, diluting the liquor in the natural reservoir in which it is collected to a point at which it could not be worked to advantage, is any run into the Clyde.

The process is being gradually improved; and it is hoped that before long absolutely no drainage of this liquor shall find its way into the river.

I am happy to say that the recovery of sulphur from these liquors, at first undertaken in order to abate a nuisance at no matter what cost, and which was not expected to yield a profit, has now proved a fairly remunerative branch of manufacture.

The following table gives an idea of the operations of an Alkali Work, based on 100 parts of Pyrites :—

RAW MATERIAL PRODUCTS AND BY-PRODUCTS OF AN ALKALI WORK, BASED ON 100 TONS PYRITES.

100· Pyrites. 1·88 Nitrate of Soda.

70· Burnt Ore.
Sold to Copper Extracting Co.
136·3 Sulphuric Acid.

160·35 Salt.

176·38 Sulphate of Soda. 274·4 Hydrochloric Acid, at 1·16 sp. gr.

47·45 Manganese. 36·81 Lime.

65·45 Bleaching Powder. 42·75 Recovered Manganese.

67·02 Coal. 123·46 Limestone. 17·63 Lime.

134·05 Soda Ash at 48 per cent. Alkali, 111·12 Waste.
or 91·63 Caustic Soda at 60 per cent. Alkali,
or 242·8 Soda Crystals.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. CIII. MARCH, 1877. No. 3.

EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Editor and the Committee of Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

American Scientific and Technical Journals.—The great improvement in our American Society and periodical publications, manifested by comparison with similar papers issued ten or twenty years since, can be accepted as the best of evidence of national advance. After taking a general departure from the *elementary* physics, chemistry, mechanics, or decorative or constructive art, the paths have diverged widely in the multiplicity of ways of applied science, and are followed by parties of enthusiastic searchers for novelties or knowledge, each party in the direction of an especial subject of interest, profit or study.

The tendency is to establish separate bodies of society organizations, which seek for members all over the land to obtain that appreciative corps of readers and those audiences which stimulate competition, and give zest to the production of the dryest of documents. The general scientific society, either national or local, must divide

into sections to obtain interesting or intelligent discussion or investigation. General science, alone and of itself, without particular application, it is recognized, is merely childish—the term implies a superficiality incompatible with progress. Our American societies have, therefore, become special and national, and the result has produced a series of society publications during the last ten years quite equal in importance to those which have been printed in any foreign land of the same population. We are a little apt to associate scientific publications solely with those bodies which are called professional; but the race of knowledge is now open to all avocations, and with the mechanical growth of the last century all industrial pursuits have become scientific. It is only within fifty years that chemistry was admitted to form part of a collegiate education. And none of the professions or pursuits which we now call "technical," have the sanction of antiquity as scientific. To-day, however, it is in the papers of the Society of Civil Engineers, the Institute of Mining Engineers, the Institute of Architects, the National Association of Wool Manufacturers, the Railway Master Mechanics' Association, of Master Car Builders, and numerous other associations of similar avocations, that we must look for the highest and most valuable contributions to technical science. The yearly or occasional publications of these societies are replete with novelties and matters of information.

Beside these permanent records, our American technical news journals, most weekly issues, contain not only a supplementary mass of purely technical knowledge, which has been elevated by the influence of the societies to a corresponding standard of excellence, but these journals are also made to be the translators of the language of the avocation which they represent, to the comprehension and instruction of that portion of the public which has to do in business, or any other way, with the particular subject. The list of these periodicals is extended and extending. Their relative circulation and popularity, other things being equal as to merits or display, of course depend on the general usefulness of, or sympathy with, their objects. Thus a paper like the *Architect and Builder*, profusely illustrated and carefully edited, will address itself not only to the professional architects, but also to all of that numerous class who build or wish to build houses, and those who take interest in church or other public buildings. There are none, from the highest to the lowest in

the community, who are not interested in buildings. Chemistry, or mining, or railway engineering may not command so many readers, even if the illustrating and editing are equally well accomplished: while other papers will only find a limited and restricted circulation and sale, with the small community of interested people they address. Patent inventions and novelties in mechanism are objects of absorbing concern to a portion of the community, and are represented by journals of rival, and on the whole, increasing merits. The more abstruse avocations, chemistry, telegraphy, photography, etc., find expression in periodicals of the highest literary attainment, and inform and gratify respective microcosms of specialists, in unknown tongues, incomprehensible to the outer barbarian. Even the minor trades become scientific and literary, and the *Lumberman*, the *Carpet Trade*, the *Tobacco Plant*, add to the stores of human knowledge, until "the ample page" can be no more unfolded, and the "spoils of time" will be lost in the waste basket, or at best, on the old book shelf.

Even the advertisements, in their descriptions and illustrations of apparatus and machinery, form no small nor unimportant part of the information, to be now and hereafter accepted as philosophical and scientific. The free use of the pencil, through the various modes of "illustration" in the current newspapers, becomes a perpetual international exhibition of the latest proposals, as well as of the established practice of mechanism in all branches of trade or manufacture. It has been a popular misconception that the scientific man was to teach the workman—the skilled artificer—the practical manufacturer. The truth is that the record has always until now been behind the accomplishment. The use and value of such record is in the perpetuation of the accomplishment as the starting point of effort by the next person who undertakes to perform the same or a similar task. But now it almost seems as if the record itself will be lost as soon as made in the multiplicity of papers and documents. It will be as finding one's route in a railway guide, to trace out any specific object from the maze of literature.

Not the least valuable or important of our scientific publications are the trades' circular books of some of the larger manufacturing establishments. One could be instanced giving the early history of the locomotive in America; another gives all the details of heating apparatus construction; while the various *tool* circulars unfold the

mystery of workmanship more thoroughly than any text book of science can pretend to. All these together register the advance of year by year with ineffaceable marks—aggregately they are building up the edifice of science, and the American press of to-day is supporting with great and noteworthy ability, the growth of civilization in our country.

With the present number of the JOURNAL, the direction of the present Editor will cease. B.

Franklin Institute.

HALL OF THE INSTITUTE, Feb. 21st, 1877.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 123 members and 9 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers, and reported that at the last meeting 10 persons were elected members of the Institute, and the following donations were made to the library:

Appendix E of annual report of the Chief of Engineers for 1876. From J. D. Kutz

Darwin by R. McK. Ormsby. From the author.

A New Treatise on Steam Engineering, by J. W. Nystrom. 1876. From the author.

Report on the mechanical properties of steel, by W. E. Woodbridge, M. D. 1875. From the author.

Report of the Trustees of the State Hospital for the Insane, Danville, Pa., 1875–6. From the Trustees.

Catalogue of the Rogers Engineering Library of the University of Penna. July, 1875. From Prof. L. M. Haupt.

Fourth Annual Report of the Board of Directors of the Zoological Society of Philadelphia. 1876. From the Society.

Specifications and Drawings of patents issued from the U. S. Patent Office for June, July and August, 1876. From the Commissioner of Patents.

Graphical Analysis of Roof Trusses for the use of engineers, etc., by Chas. E. Greene. Chicago, 1876. From Geo. H. Frost.

Philadelphia and its environs. Die Technik der Baumwollenspinnerei, by Hülsse. Stuttgart, 1863. Gilbart's Treatise on Banking. Dinham's map of the environs of Manchester. The Conservation of Energy, by B. Stewart, 1874. Mechanic's Tool Book, by Harrison, 1868. Religion and Science, by Jos. LeConte, 1874. Handbook of Bookkeeping, London, 1860. Handbook of Business, London, 1860. Phelps' New York City Guide, New York. Der Ingenieur, von Dr. Weisbach, 2d and 3d Vols., 1861 and 1863. Lehrbuch der ebenen Trigonometrie, nebst vielen Uebungsaufgaben, by Dr. Wiegand, 1860. Die Anwendung der Algebra auf praktische Arithmetik, von W. Berkham, 1859. Erster Cursus der Planimetrie, 1866. Die höheren bürgerlischen Rechnungsarten, 1850. Lehrbuch der allgemeinen Arithmetik, 1866, by Aug. Wiegand. From Rob't H. Hoz, Philad'a.

Transactions and proceedings of the Royal Society of New South Wales for 1875. Vol. 7. Mines and Mineral Statistics of New South Wales, etc., 1875. Mineral map and general statistics of New South Wales, Australia, 1876. Transactions of the Philosophical Society of New South Wales, 1862—1865, Sydney, 1866. New South Wales, its progress and resources, by authority of the Commissioners, 1876. Results of Meteorological Observations made in New South Wales during 1873, Sydney, 1875. From the Royal Society, N. S. W.

Forty-third Annual Report of the Royal Cornwall Polytechnic Society, 1875. From the Society.

K. K. Geologische Reichsanstalt. Catalog der Ausstellungs-Gegenstände bei der Wiener Weltausstellung, 1873, Wien. From the K. K. Geol. Reichsanstalt.

Biographical Notes concerning General Richard Montgomery, together with hitherto unpublished letters, 1876. Catalogue of books in the library of the Manchester Literary and Philosophical Society, 1875. Memoires of the Literary and Philosophical Society of Manchester, Vol. 3, 3d Ser., 1876. From the Society.

Report of the Commissioner of Education for 1875. From the Commissioner.

A concise history of the Iron manufacture of American Colonies, etc., by J. B. Pearse, 1876. From the author.

Report of the Board of Commissioners of the State Survey, N. Y. 1877. From the Board.

Rules, regulations and forms of the Canada Patent Office. Sept. 1, 1872. An Act to further amend the Patent Act of 1872. From the Canadian Patent Office.

Polar Colonization and Exploration. From H. W. Howgate.

Bulletin of the U. S. National Museum No. 4. Birds of Southern Mexico, by S. N. Lawrence, Wash., 1876. Bulletin of the U. S. Geolog. and Geographical survey of the Territories, Vol. 2, No. 4. Wash., Aug. 4, 1876. Classification of the collection to illustrate

the animal resources of the United States, by G. Brown Goode. Wash., 1876. The Mineral Wealth, Climate and Rain-fall and natural resources of the Black Hills of Dakota, by W. P. Jenny. Wash., 1876. Report on the Geology of the Eastern portion of the Unita Mountains and a region of country adjacent thereto, with atlas, by J. M. Powell, Wash., 1876. Report of the invertebrate cretaceous and tertiary fossils of the upper Missouri country, by F. B. Meek, U. S. G. S. of the territories, F. V. Hayden, Geologist in charge. Wash., 1876. Vol. 9, and monograph of the Geometrical Moths or Phalænida of the U. S., by A. S. Packard, Jr., Vol. 10. From the Department of Interior, Z. Chandler, Secretary.

Annual report of the Secretary of Internal Affairs of the commonwealth of Pennsylvania, for 1874–5. Part 3. Industrial statistics. Vol. 3. From W. H. Grier.

Fifth and sixth annual reports of the board of commissioners of public charities of the State of Pennsylvania, for 1874–75. Harrisburg, 1875–6. From the board.

Papers relating to the foreign relations of the United States, transmitted to Congress, with the annual message of the President, Dec. 4, 1876. Washington, 1876. From the department of State.

Illustrations to accompany the annual report of the commissioners of Patents, for the years 1869–71. Washington, 1876. From the commissioners of patents.

Twenty-fourth annual report of the president, treasurer and librarian of the Mercantile Library Association of San Francisco. 1876. From A. E. Whitacker, librarian.

The Secretary reported from the Committee on Science and the Arts, that at the last meeting it recommended to the Board of Managers the award of the Scott Legacy Premium and Medal to Geo. B. Grant for his calculating machine, and to G. L. H. Behrns for his high-pressure aspirator for ventilating mill stones.

Mr. Wm. Welsh, chairman of the Committee on Primary Industrial Education, reported verbally that the committee had made considerable progress in the work submitted to it, and that the more they study the subject, the more important and timely is the appointment of the committee found to be. He asked that the committee be continued, which was agreed to.

Mr. Geo. R. Moore was then introduced and read the paper announced for the evening, on Schools for Inventors.

The Secretary presented his report which embraced Clark's Compound R. R. Rail; Robinson's Odontograph for laying out the teeth of gear wheels; Morris, Wheeler & Co.'s chisel-pointed Nail; an exhaust Nozzle for quieting the noise of safety valves, escape pipes,

etc., the invention of Mr. Thos. Shaw; Behrns' Aspirator for ventilating millstones; a Horseshoe intended to prevent slipping on smooth pavements; a new form of Megascope, designed by J. B. Knight, and the Wallace-Farmer Magneto-Electric machine, built by Messrs. Wallace & Sons, of Ansonia, Conn. One of these machines, loaned by the builders to the Committee on Instruction for use in lectures, was in operation on the stage and its power was shown by vaporizing metals, etc., and its construction and action explained at some length by the President.

The Magneto-Electric machine was driven by an upright steam engine of 6 in. diameter of cylinder and 8 in. stroke, recently purchased by the Institute from Mr. Jacob Naylor.

Under the head of new business, the Resolution of Mr. F. M. M. Beale, relative to Polar Exploration, postponed from the last meeting, was taken up and on being put to a vote was adopted, as follows:

WHEREAS, A Bill is at present pending before Congress asking aid for carrying into execution the scheme of Capt. H. W. Howgate, of the Signal Service, for reaching and exploring the region about the North Pole on the plan of colonization,

Resolved, That the Franklin Institute approves of this plan, not only for its economy, but for its apparent practicability, and believes it to be the most feasible plan yet offered.

On motion of Mr. Orr, it was

Resolved, That the Secretary be directed to send a copy of above Resolution to both Houses of Congress.

On motion the meeting adjourned.

J. B. KNIGHT, *Secretary.*

Donations continued from January Number.

Annual Report of the New York Meteorological Observatory for 1874–5, by D. Draper, Director. From the Director.

Bibliotheque Universel et revue suisse, N. 217, with table des travaux de la revue, etc. Note sur les elèves externes de l'école des Ponts et chaussées par M. Malézieux, Paris, 1875. Ecole des Ponts et chaussées. Cour preparatoires. Catalogue du Cercle de la libraire de l'imprimerie, etc. Paris, 1876. Exposition Universelle de Philadelphia, 1876.

Etude historique et statistique sur les voies de communication de la France, etc. Par M. Felix Lucas, Paris, 1873. Exposition Univ. à Vienne.

Catalogue descriptive des Modéles, Instruments et dessins des galeries de l'école, par H. Baron, Ing.-en-Chf, Paris, 1873. Ecole National des Ponts et chausseés. From E. Lavoinne, Delegate from French Government.

The Economy of Workshop Manipulation, etc., by John Richards. From the Author.

Second Geological Survey of Pennsylvania, 1874–5. Report of Progress in the District of York and Adams Counties, etc. By Persifor Frazer, Jr. Harrisburg, 1876. Report of Progress in the Greene and Washington Districts of the Bituminous Coal Fields of Western Pennsylvania, by J. J. Stevenson. Harrisburg, 1876. From the Board of Commissioners, through their Secretary, Mr. J. B. Pearce.

Instruments and Publications of the U. S. Naval Observatory, 1845–76. Five Photographs of Planet of Saturn, etc. Five Photographs of Drawings, made with 26 in. equatorial in 1875. One Engraving of U. S. Naval Observatory, Washington. From U. S. Naval Observatory, through Prof. J. E. Nourse, Washington.

Extracts from the Proceedings of the Board of Regents of the Smithsonian Institution in Relation to the Electro-Magnetic Telegraph. From Prof. W. S. Cooley.

Twenty-fourth Annual Report to the Council of the City of Manchester, on the Working of the Public Free Libraries, 1875–6. Manchester, 1876. From the Council.

History of the Cooper Shop Volunteer Refreshment Saloon, by Jas. Moore, M.D. Philadelphia, 1866. From Mrs. A. Horner, Philadelphia.

Sections of Steel and Iron Rails Manufactured by Cambria Iron Co., Johnstown, Pa. From the Company.

Minutes of Proceedings of the Institution of Civil Engineers, Vol. 46, Session 1875–6, Part 4. Edited by Jas. Forrest, Secretary. London, 1876. From the Institution.

Catalogue of the Argentine Republic, International Exhibition. Philadelphia, 1876.

Catalogues des produits industrielles et des œuvres d'art de Belgique. Exhibition International, Philadelphia. Bruxelles, 1876.

The Empire of Brazil at the Universal Exhibition of 1876, in Philadelphia. Rio de Janeiro, 1876.

Catalogue of the Brazilian Section, Philadelphia International Exhibition, 1876.

Official Catalogue of the British Section, Part 1, Philadelphia International Exhibition. London, 1876.

Centennial Newspaper Exhibition, 1876. N.Y.

Ceremony of the Distribution of Awards to Exhibitors in the International Exhibition, Philadelphia, 1876.

Lista preparatoria del Catalogo de los expositores de España y provincias de Ultramar, Cuba, etc., Exposicion Universal de Filadelfia en 1876.

Oeuvres d'art et produits industriels de France. Exposition international, Philada., 1876.

Official Catalogue of the German Department. International Exhibition. Philada., 1876. Berlin, 1876.

India. Classified and descriptive catalogue of the collections selected from the India museum, and exhibited in the Indian Dept. of Philadelphia Centennial Exhibition of 1876. By J. F. Watson. London. 1876.

Catalogo general de los productos y objetos de las Islas Filipinas remitidos a la Exposition Universal de Filadelfia, 1876. Manila.

International Exhibition, 1876. Official catalogue of the seven departments in 4 Vols. Philadelphia.

Official catalogue of the Japanese section, and descriptive notes on the industry and agriculture of Japan. International Exhibition. 1876. Philada., 1876.

Jamaica. Descriptive catalogue of the collection sent from the Island to the Centennial Exhibition of 1876. Compiled, etc., by R. Thomson. Jamaica, 1876.

Kansas. Centennial edition of the fourth Annual Report of the State Board of Agriculture to the Legislature of the state. 1876.

Special catalogue and explanatory notes of the Mexican section. Philada. International Exhibition, 1876. Philadelphia, 1876.

History of Nassau, N. P., Bahamas.

Ohio. An address, delivered at the Centennial Exhibition in Philadelphia, August 9th, 1876, by E. D. Mansfield. Cleveland. 1876.

Sketch of Orange Free State of South Africa. Issued by the Commissioner at the Int. Ex., Philada., 1876.

Oesterreichischen Abtheilung. Katalogue. Weltausstellung in Philadelphia, 1876. Wien.

Annual report of the packing of the West, etc., compiled by B. F. Howard. Chicago, 1876.

Catalogue of the Educational exhibit of the state of Pennsylvania, with an appendix, containing an outline of the system of public instruction in the state, Centennial Exhibition. Lancaster, 1876.

Official catalogue of the Peruvian section, Main building, International Exhibition, Philad'a, 1876. N. Y.

Catalogue of the Russian section, International Exhibition, Phila., 1876. Russia, 1876.

Special catalogue of stated displays of Live stock, International Exhibition, Philadelphia, Oct. 10–18, 1876.

Official catalogue of exhibits, essays, etc., of Victoria, Australia, Philada. Centennial Exhibition, 1876. Melbourne, 1876.

Resources of West Virginia, by Maury & Fountaine. Wheeling, 1876. From P. C. De Sangue, Philad'a.

Public Libraries in the United States of America, their history, condition and management. Special report Dept. Interior, Bureau Education, parts 1 & 2. Washington, 1876. From Hon. Com. of Education.

Programm der Grossherzoglich Badischen Polytechnischen Schule zu Carlsruhe, für das Studienjahr 1866–67.

Astronomie geometrique ou brèves considerations sur les nouvelle theorie des ovhélites, par le Comte Leopold Hugo. Paris, 1876.

Ueber die Entstehung des Schwärmsprösslings der podophrga quadripartitæ. Clp. u. Lehm, etc., von Dr. Otto Butschli. Naumburg, 1876.

The Empire of Brazil at the Universal Exhibition of 1876, Philadelphia. From the Smithsonian Institution, Washington.

Donations continued from February Number.

Reports upon geographical and geological explorations and surveys west of the one-hundredth meridian in charge of first lieut. Geo. M. Wheeler. Vol. 3, geology; vol. 5, zoology. Washington, 1875.

Report of the exploring expedition from Santa-Fé, New Mexico, to the junction of the Grand and Green rivers of the Great Colorado of the West, in 1859, under command of Capt. J. V. Macomb, with geological report by Prof. J. S. Newberry. Washington, 1876.

Report of explorations across the great basin of the territory of Utah, for a direct wagon route from camp Floyd to Genoa, in Carson valley, in 1859, by Capt. J. H. Simpson. Washington, 1876. From the war department.

(To be continued.)

Book Notices.

A Concise History of the Iron Manufacture of the American Colonies up to the Revolution, and of Pennsylvania to the Present Time. By John B. Pearse, A.M. Allen, Lane & Scott, Philadelphia, 1877. 12mo, 282 pages, with Map of Pennsylvania. $2.00.

Those who are interested in the history of our country, as readers or as students, as well as those engaged in the iron trade or manufacture, will turn with much pleasure to this interesting narrative

account of the origin and growth of the iron manufacture in our country. Other metallic productions may inure to the luxury or wealth of a people, as the possession of gold and silver fostered the greatness of Spain in the days of its prosperity; but it is the manufacture of iron that, paramount to all other industries, develops the labor and establishes the independence of a nation. In these modern times especially, the measure of the civilization of any nation is founded on the construction and employment of the mechanism involved in the uses of iron and steel.

In the preface, "The author hopes that the publication of the book at this time may bring to light additional facts, so that at some future time he may have the opportunity to complete it, and include all the States as thoroughly as Pennsylvania." With this purpose in view, it would have been much better if he had given the sources of information from which it was compiled. Even a bibliographical list would have sufficed, but it would have been yet better to have placed foot-notes of authorities for each statement, which would not have encumbered the text with matter wanting in interest to the general reader, while they would have given a historical accuracy and importance to the book, which it now wants.

The history, or accessible record of iron making, is considered in the several Provinces, commencing with Virginia and following with other Colonies in their order of settlement, and tracing, with some regard to chronological sequence, the origin and progress of the industry. It is unavoidable, in the compilation of material of this kind, that some of the information should come to hand too late for the preservation of perfect continuity of narrative; but no material changes, none that the reader will not at once effect in his own mind, will be demanded to give the proper historical arrangement of events.

Some of the deductions are a little incongruous. Thus we read, under the head of "Massachusetts": "Notwithstanding the early progress of Virginia, the colony of Massachusetts Bay was neither idle nor far behind Virginia in making iron. Virginia made, indeed, the first iron, but very little of it, and the attempt was abandoned before Massachusetts began." * * * "The first iron works in Massachusetts was that at Lynn, mentioned in the records of the Sixth Church of Christ, held at Lynn, 1631" * * * "Here is also an iron mill in constant use." This record causes one to look

back to Virginia, and see what was the early progress referred to. "The first iron made in this country was made in Virginia. Capt. John Smith early called attention to iron ore in Virginia, and Sir Thomas Gates (1610) mentioned iron ore ten miles in circuit, of which we have made trial at home [in England]; that it makes as good iron as any in Europe. In April, 1608, ore was sent from Jamestown to England, which was smelted in the autumn, yielding seventeen tons of pig metal," a fact which is corroborated by the statement that "it was sold to the East India Company for £4 sterling per ton." Sir Edwin Landys (1620) says that "one hundred and ten iron workers from Warwickshire and Staffordshire, and forty from Sussex were sent to Virginia to erect three iron works." One of the proposed three is stated to have been commenced, and it was "certified by Mr. Berkely, that by Whitsuntide next (1622) iron would be made." "But, alas! in 1622 (March 22d) Mr. John Berkely, with twenty-two men, two women and three children, were massacred by the Indians, and the works destroyed before they got into the body of the mines (Beverley). *The iron proved reasonably good* [the italics are the reviewer's]. Maurice Barkley was directed to employ the survivors, and rebuild the works; but in 1624 the Virginia Company was dissolved by royal decree, and the whole enterprise fell to the ground." There does not appear to be any evidence that iron was made in Virginia at that time, nor at any other prior to 1715, except by inference.

It will probably be found, if this book stimulates inquiry amongst the old records, that the Colonies, from the first years of their settlement, produced more or less forge iron in a small way. The colonists included numbers of working mechanics. Emigrants are always mainly tradespeople and working men. Farmers and farm laborers have a land attachment, which it is difficult to break. And the smith's art is the earliest to find employment in a new settlement. Under the protection of the heavy cost of bringing iron from the mother country, and the absolute want of money or exchangeable commodity to pay for it, with the advantage of a more than abundance of wood to make charcoal, while the forests of England were even then in good part cut away—under these circumstances the making of iron was stimulated at once into a business. The little forges wherein wrought iron was made by the sinking process were probably numerous, although as few records would remain of them, as

of the shoemakers' benches or bakers' ovens. While the larger furnaces, or bloomeries, or hammer mills, which would follow the growth of the settlement, would be matters of public regard and note.

The policy of Great Britain towards the Colonies, the effort, as they grew stronger, to preserve them in utterly dependent positions, the course of protection of her home industries, the intelligent pursuit of which has finally made her the seat of the arts and sciences, the mistress of nations, is strikingly exemplified in one part of this book.

The reader will find on referring to pages 121 and following, the Act of Parliament of 1749. "*To encourage the Importation of Pig and Bar-Iron from His Majesty's Colonies in America into the Port of London and to prevent the Erection of any Mill or other Engine for Slitting or Rolling of Iron; or any Plating Forge to work with a Tilt Hammer or any Furnace for making Steel in said Colonies.*" A very brief summary of this Act is as follows:

The Act was to go into effect on the 24th of June, 1750; it abolished all duties then in force on colonial pig or bar iron imported into any part of England, and permitted pig or bar iron to enter the port of London free of duty, but it was not permitted to enter iron at any other place in the kingdom of Great Britain, and after its arrival at London it could not be shipped from London or transmitted by land further than ten miles, in any unmanufactured state. Ships transporting were to be forfeited and seized—punishments and penalties awaited masters or commanders—forfeitures and fines were to be inflicted on carriers on horseback, in wagon, cart or carriage.[1] Every bar was to be stamped in three places (and forging of a stamp was a capital crime, to be punished by hanging in those days).

"No Mill or other Engine for Slitting or Rolling of Iron or any Plating Forge to work with a Tilt Hammer or any Furnace for making Steel shall be erected, or after such Erection continue, or cause to be continued, in any of the said Colonies, under penalties of £200, for such Mill, Engine, Forge or Furnace. Such Mill, Engine, Forge or Furnace so erected or continued * * shall be deemed a common nuisance and abated accordingly, with forfeiture of £500 by the

[1] In 1756, the trade was made free to any port in Great Britain, and in 1765, to any port in Ireland, but otherwise the law, with its restrictions against Slitting, Rolling, Plating or Steel making, remained in force until the Revolution.

offender, and disability to enjoy any office of Trust and Profit under His Majesty, his heirs and successors."

Following the suggestion of the author as to the eliciting of new facts on this subject, it is ventured to publish the accompanying correspondence and memorial from the original manuscripts in possession of Henry Pemberton, Esq., of this city, relating to this Act.

The writer, Richard Partridge, Esq., was then Agent of the Province of Pennsylvania, in London, and his correspondent, John Kinsey, Esq., was Chief Justice of the Province.

London 12 *mo. the* 28*th* 1749.

Lo: Frd: John Kinsey

I wrote thee of the 22d & 26th ult. by the late ships for Philad^a to which I refer—& now I was not willing to omit sending thee a few lines by this conveyance also—

I think I mentioned something to thee of a Bill that was brought into the House of Comons for taking off the Duty on Iron Bars & Pig Iron imported from the Plantations, but since that a clause is added to the Bill for preventing their making Steel & Setting up of Slitting Mills & Rolling Mills in the said Plantations which we apprehend would greatly tend to their prejudice & be an Infringement on the priviledges of the Charter—And thereupon I have drawn up some Reasons ag^st that Clause which I yesterday communicated to your Proprietor Penn who approved it proposing only a little variation & a small addition, which we intend to make a proper use of as there shall be occasion, a copy whereof comes inclosed. But altho the Bill is espoused by the Ministry yet it is thought there will be such opposition to it from some of the Countys that it will hardly pass—

Nothing yet is passed in the House this Sessions relating to Paper Currency I am Thy real friend

R^d Partridge

Objections against a Clause in the Iron Bill

To prevent the making of Steel and Setting up Slitting Mills and Rolling Mills in the British Colonies in America

That the Province of Pennsylvania & New Jersey & the Colony of Rhode Island have been peopled & at great expence settled by means of certain Priviledges which were granted by the Crown & have shown the utmost Duty at every Intimation of the Royal Pleasure & have made such Reasonable & prudent use of those Indulgences w^h have been granted by the Crown that the said Provinces and Colony are now become flourishing Plantations in his Majesty's American Dominions

That by Virtue of Charters granted by King Charles the Second, the People who should Settle & Inhabit within the said Provinces and Colony should have and enjoy all libertys & Immunitys of Free & natural Born Subjects to all Intents Constructions & Purposes whatsoever as if they were born in the Realm of England.

That the Several Tracts of Lands together with all Mines, Minerals &ca were for their Encouragement by the said Charters granted to the respective Proprietors as their own & intire Property

That the said Provinces & Colony did at their own Expence and without any charge to the Crown, Settle, Inhabit, Cultivate & improve the Lands of a Wilderness Country well hoping that they and their Successors should constantly for ever enjoy all and every those Libertys Franchizes & Priviledges so granted by the Royal Charters who have approved themselves dutyfull & Loyal Subjects of great and singular advantage to this Kingdom, by taking off vast quantitys of the British manufactures Annually

That the Clause aforesaid for preventing the making of Steel and Setting up Slitting & Rolling Mills in the British Colonies in America now depending in the House—It is humbly presumed will be exceeding prejudicial and discouraging to the Inhabitants of the said Provinces and Colony in that there are diverse sorts of Iron Materials constantly wanted & in use amongst them to be made out of Rods of Iron which cannot readily be had from their Mother Country nay impossible to be accommodated with suitable to the Necessitys required Particularly Horse Shoes & Horse Shoe Nails, so absolutely necessary that without them their Horses (of which there are great Numbers) wou'd be render'd in a manner useless; and Iron Screws & Rods for their Bedsteads & other Household furniture with innumerable other things necessary for Carpenters & Joyners work &ca

That the Proprietors of the Slitting Mills already erected in some of the said Plantations, have been at very great expense in building & Setting them up which should such a Law pass as is now proposed would be a very great hurt & damage to their Property.

That Steel is absolutely necessary for working up their Edge Tools Particularly their Axes for Felling their Timber Trees which beside their Iron there is most properly Suitable for the Purpose; they are made in such a peculiar manner, & which the People of that Country are accustomed to.

That as the Inhabitants of the said Provinces and Colony are by His Majesty's Royal Grants as aforesaid allowed to be Free Dennisons as any of his Subjects born in this Realm so they cannott but esteem it avery great hardship and an Infraction of the said Royal Charters now after so long a time of Enjoyment of their Priviledges and Immunitys as English men to be deprived thereof by being debarred of that natural right of Improving to the best advantage what Nature hath put in to their hands so absolutely necessary for the Conveniences of Life.

Added by ye Propriet. Penn

And it is further conceived that this Clause will not be of Advantage to Great Britain as by how much of the Iron Manufactures it will oblige them to take from this Kingdom by so much less they will have to pay for Woolen Manufactures which the Severity of their Winters render very necessary to them.

And therefor for these Reasons it is humbly hoped the said Clause will be rejected.

It would be highly gratifying to the writer of this notice to pursue this interesting book through the more modern record of iron making in the United States; but the limit of space in the JOURNAL is already reached, if not surpassed. Now that a point of aggregation has been established, it is to be hoped that contributions will flow in upon Mr. Pearse, so that he can at a future time add considerably to this history. The reviewer is unwillingly obliged to conclude in recommending Pearse's History of the Iron Manufacture as worthy to be read and preserved as a standard work in the general history of our country, and in the progress of the arts, as applied in the wider sense to the world's advancement. B.

NEW ENCYCLOPEDIA OF CHEMISTRY. Lippincott & Co., Philadelphia, 1877. Issued in 40 parts (Parts XVI to XX now published), at 50 cents each.

The previous favorable notices of this admirable work are fully supported in its continuation. As a book of reference in practical chemistry, it is alone amongst the recent encyclopedias. For the operating chemist it gives a record, down to the present hour, of applications which have stood the test of actual use; and for the manufacturer of any product, who would know the relations of chemistry to his business, it contains the most ample description of processes and results. Being based on a former standard of the highest excellence, its completeness is insured by the additions which are liberally made, until, without deserting any of the old store of knowledge, the whole is, in effect, a new work, giving the present condition of chemical arts, with all its change and growth for fifty years.

GRAPHICAL ANALYSIS OF ROOF TRUSSES, by Chas. E. Greene, A. M., Prof. of Civil Engineering, University of Michigan. Pp. 64, 8vo. G. H. Frost, Chicago, 1876.

This republication of Articles on Roof Trusses, which first appeared in the *Engineering News*, in such form that it will be a convenient book of reference to go on the shelves of the engineer or architect, is very satisfactory, as the study really possesses so much value in constant practice as to make this disposition of it desirable.

So many references to the graphical consideration of stresses have appeared in the JOURNAL during the past three years, that the readers must fully appreciate the estimation in which the method is held by the editorial direction, and this presentation of Prof. Greene will be found at once simple, clear and reliable, and hence can be highly recommended. B.

Civil and Mechanical Engineering.

CERTAIN POINTS IN THE DEVELOPMENT AND PRACTICE OF MODERN AMERICAN LOCOMOTIVE ENGINEERING.

By Francis E. Galloupe, S. B.

[Continued from Vol. ciii, page 113.

The Mack's injector with which this locomotive is supplied, is of the fixed nozzle, lifting form, and has been exclusively used upon the engines of the Eastern road since 1872. The diameter of the connections of the No. 6, is $1\frac{1}{4}$ inches; it will lift water from five to eighteen feet, at from 15 to 40 lbs. pressure, and deliver 870 gallons per hour, or from 116 to 134 cubic feet of water at 120 lbs. pressure. The rule by which they are ordered is, assuming the nominal horse power of the boiler to be equal to the number of square feet of heating surface divided by 15, for a multitubular boiler, each nominal horse power will require $7\frac{1}{2}$ gallons of water per hour, and the capacity needed is so determined.

To show the general arrangement of parts, the position and principle of this injector, I have drawn it in its real position upon the boiler in plate *A*, and made the following sectional view. Its position is horizontal and in this case just above the running board. Its parts consist of a starting valve *A*, the steam pipe *B*, conical *receiving*, *combining*, and *delivery* tubes, shown respectively at *b*, *c*, and *e*, in the sectional view, the steam spindle *I*, water regulating handle *H*, water supply pipe *C*, overflow pipe *E*, the delivery pipe *D*, and check valve *F*.

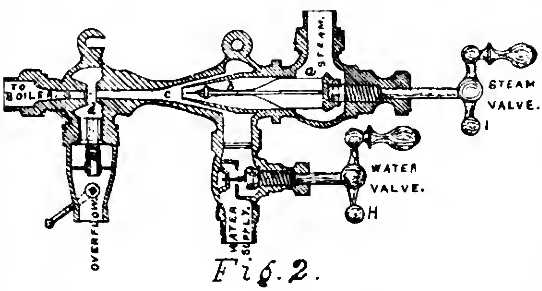


Fig. 2.

It may be operated by opening the three valves *A*, *H* and *I*, in various orders, and its action may be described as follows:—To start the injector, the steam valve *I*, is first opened, by which any condensed steam in the apparatus is blown out through the overflow which opens into the air within the cab. Then, 1st, the water valve *H*, is opened, which causes a stream of water to flow through the supply pipe *C*, plate *A*, through *c* and *d*, Fig. 2, and out at the overflow. 2d, the starting or steam valve *A*, is opened from one-eighth to one-fourth of a turn. By this means dry steam from the boiler enters the injector at *a*, and passes by the feathers of the steam spindle *b*, which is in what is called the receiving tube, since it receives the live steam from the boiler. It thence passes into the combining tube *c*, where it is condensed by the water, and without losing its own velocity, imparts an additional velocity to a portion of the water which it takes up, carries across the opening in the overflow *d*, into the delivery tube *e*, and pipe *D*, in the plate, and forces through the check valve *F*, into the boiler. 3d, the steam spindle is next fully opened, by which more and more of the water is taken up; and 4th, if any remains flowing out through the overflow, it is cut off by slowly turning off the water valve *H*. To stop its action, the steam valve *A*, the water valve *H*, and the steam spindle *I*, are in succession turned off.

Such, in brief, is the action of this instrument in its simplest form. In the self-regulating form, the combining tube *c* is movable, and its distance from *b* regulated by a piston, acted upon by the pressure of the overflow water. This piston, by moving the tube *c* against the outside of *b*, cuts off the water supply; and the injector has also an alarm check valve in the supply pipe, which lifts if there is any failure of the valves to work.

The principle of the injector is as follows:—It is that known as the "lateral action of fluids,"[1] and was discovered by Venturi and Nicholson, about seventy years ago. The velocity with which the steam enters the receiving tube at 120 lbs. pressure is 1900 feet per second, and on reaching the water in the combining tube, its bulk and cross-section, by its condensation, are reduced from 200 to 1500 times; let us say for example 1000. But its velocity or actual energy

[1] Roper's Handbook.

is not destroyed as it comes in contact with a thin ring of water, which would be the case if it encountered a large mass, and it is hence communicated to the water, whose energy, proportional to its weight, multiplied by the square of its velocity, drives it into the boiler against the steam pressure, with great momentum. It is equivalent to concentrating the original force due to the pressure of the steam upon a cross-section of but $\frac{1}{1000}$ of its original area.

The injector is the most elegant of all the applications of science for practical use, in the locomotive.

Connected with the subject of boiler feed is that of *feed water heaters*, into the discussion of which I will not here enter. The utility of these arrangements lies either in the use of the waste heat of the furnace or of the enormous amount carried off by the exhaust steam. The difficulties which stand in the way of their use are, that the former are complicated and expensive to keep in repair and obstruct the course of the gases through the smoke-box, and the latter tend to lessen the draught through the smoke-stack, while in both the saving theoretically demonstrable is much diminished if not neutralized by the items of expense in first cost, interest, deterioration and repairs, complexity and the increased liability for the engine to get out of order.

Mr. M. N. Forney[i] states the ruling principle by which to decide in each case whether there is at present any real benefit or not from their use, to be this,—"if it diminishes the maximum capacity of the engine for pulling cars, it diminishes the efficiency in the same proportion." Although the Magoon heater is simple in design and has been in use upon the "Saxon," on the Boston and Maine Railroad, where it is said that it caused a saving of about three-quarters of a ton of coal per day, for four months in succession, and the apparent saving by its use is a matter of very easy calculation, yet I have the opinion of one[ii] most interested in effecting such saving, who says that all such contrivances, including the spark arresters, are not as efficient as representations would seem to show, and the fact that they are not universally used after having had a fair trial would seem to indicate that there is at present no real gain in economy by their use.

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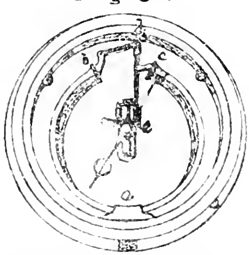
[i] In Ed. *Railroad Gazette*, Sept. 11th, 1875.

[ii] Mr. Jno. Thompson, Master of Machinery, E. R. R.

IV. The Safety Apparatus forms a large portion of the locomotive boiler fittings. It may be classed as of two kinds, those parts which insure the safety of the boiler directly, and those which are added for the protection of the engineer and his train, and the public. The first of these are the safety valves, steam gauge, water gauges, gauge cocks and lead plugs, formerly used in the crown sheet of the fire-box; the second includes the air or vacuum brake, the steam dome and whistle, the bell, head-light, spark-arrester, running boards, hand-rails, foot-board, cab, wheel-guards, pilot, down to the brooms of steel wire, by which small obstructions are removed from the rails. The spark-arrester in this locomotive, consists in the wire netting stretched between the cones, placed base to base, which form the upper part of the smoke-stack. The office of these is, the first, by enlarging the cross-section of the pipe to diminish the velocity of the particles of coal, and the second, or upper, to deflect them downward again. The two pieces of apparatus first mentioned only, need further description, the others being indicated in plate *A*, of the drawings, and in the specification.

Of the Steam Gauge there are a number of forms, such as the Bourdon, Edson, Allen, Crosby, and Lane. The principles upon which they all work are, in one class, the moving of an index over a graduated arc by means of the pressure of steam acting upon an elastic diaphragm, in a similar manner to that in an Aneroid barometer; or in the other, upon a curved tube of flattened cross-section.

Bourdon Gauge.
Fig 3.



Lanes Improvement.
Fig. 4.

The gauge with which this locomotive is supplied, is the Bourdon form, having Lane's improvement, and manufactured by the American Steam Gauge Co. in Boston.

Both the original and its modified form are exhibited by the accompanying figures.

On account of the importance of this instrument to the locomotive boiler, a short description of its construction, from observations made during an afternoon's visit to the American Steam Gauge Company's Works, may be given.

The principle of the Bourdon gauge was discovered in rather a curious way, by Mr. Bourdon, a coppersmith, of Paris. A worm for a still, which he was repairing, having accidentally become bent or indented, and thinking that by applying internal pressure on the pipe the dent could be removed, he did so, and observed, to his surprise, a slight motion of the coil. From this he was led to a study of the cause of the tendency he observed—that of a bent tube of flattened cross-section to straighten when subjected to internal pressure, and invented the first form of steam gauge. Previous to its use, the manometer, or short mercury column, and the lever and spring balance attached to the safety valve, and provided with an index and scale, were the only arrangements for the indication of pressure upon locomotives. On this discovery the Bourdon gauge was constructed, and introduced by Mr. E. H. Ashcroft, about a year later, into this country, in 1851. As shown, it consists of a tube, having an elliptic cross-section, bent into a circular form, and attached, by one extremity, *a*, to the case, communication being made between its interior and the steam pressure through the pipe below. The other end moving, turns the lever *b*, and the toothed segment, which at one end gears into a pinion *c*, and so gives motion to the hand.

Although in this gauge there was a bend, or U, in the pipe connecting the boiler and the gauge, for the purpose of collecting the condensed water, it was found that a detached portion of water would remain suspended midway between the extremities of the curved tube, and often burst it by freezing, or cause inaccuracies in the indications. This is now prevented in Lane's improved form. The tube is held at the middle, *a*, Fig. 4, one end, *b*, connected with the lever, *d e*, which has a toothed segment, turning a pinion on the spindle of the index, as before. If the end, *b*, moved alone, *e* would be the fulcrum of this lever; if *e* alone moved, the lever would turn about *d*. As both ends, however, move apart together, when under internal pressure, the motion of the whole is utilized, as in the old form, and much greater steadiness obtained. From the construction any water in the ends of the tube would run out, and, in practice, the ends of the tube contain compressed air. The curved tube is originally straight and round, $\frac{5}{8}$ inch in outside diameter, and made of a hard composition. By repeatedly drawing

through dies, its elliptic cross-section is produced of the following dimensions :

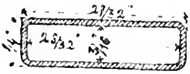


Fig. 5.

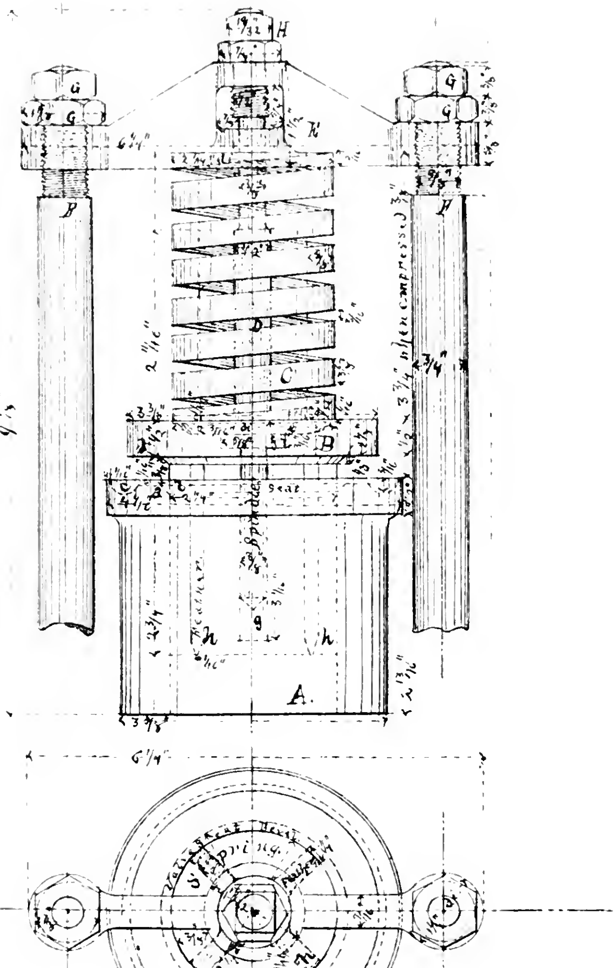
The tube, hardened by this drawing process, is then bent into circular form, after filling its interior with sand; tested to 150 or 160 lbs.; fixed with the index and dial plate in the case, and the gauge graduated by the mercury column. The division marks upon the gauge are then carefully cut, the lettering stamped and filled with black wax, or asphaltum, the brass silvered with chloride of silver, and the gauge completed.

The cause of the tendency of the bent tube to straighten, is the same as that acting upon the boiler shell. Pressure tends to round out the flat sides till the tube becomes circular, and of its original $\frac{5}{8}$ inch diameter. As it approximates to this, its outer side would have to be lengthened and inner side compressed, in order to preserve the same radius of curvature; and hence its radius increases as it straightens, and throws the ends apart.

A Safety Valve consists of a circular disk, which closes a corresponding opening in the boiler. Of these, the locomotive boiler is fitted with two spring valves of the Richardson form, each $2\frac{1}{4}$ inches in diameter, and of precisely similar construction. To illustrate the size and arrangement of parts, I have made a drawing from measurements of one of these, as shown in Plate VI.

The valve, *B*, of brass, which has a conical face $\frac{1}{8}$ inch in depth, and feathers, *h*, for the guidance of its motion, fits accurately a seat in the brass cylinder *A*. It is held down to its seat by the steel spring, *C*, which is represented as compressed $\frac{3}{8}$ inch, and by means of the cross piece, *E*, and bolts, *F F*, which are fixed into the boiler. The spindle *D*, and the screw bolt *H*, serve to adjust the lift of the valve.

In order to have the opening of the valve equal to its area, this lift, h, would be found, by the equation, $\frac{1}{4}\pi d^2 = 2\pi r \times h$, whence $h = \frac{1}{4} d$; but actually, from the increasing force necessary to compress the spring by equal amounts, the greatest lift of the valve may be taken at $\frac{1}{20}$ of an inch. Now, since the coning of this valve is 45°, the real opening for the escape of steam is but $\frac{7}{10}$ of the lift, or $\cdot05 \times \cdot7 = \cdot035$ inch. To show plainly what this amount is, the figure below has been drawn *full size.*



Richardson's 'Pop' Safety Valve for Locomotives.

Scale, 3/8" = 1'

F. E. Galloupe.

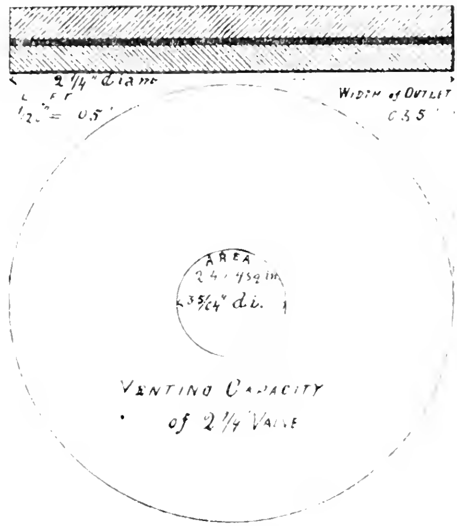


Fig. 6.

The area thus opened for the passage of the steam is but $2\,\pi\,r \times \cdot 035 = \cdot 2474$ square inch, corresponding to a pipe a trifle over $\frac{1}{2}$ in. in diameter. Prof. Burg, of Vienna, has found, from actual measurements, that at only 12 lbs. pressure the rise was but $\frac{1}{36}$ inch, and that it rapidly *decreased with increase of pressure*, till, at 90 lbs., the opening was but $\frac{1}{168}$ inch. With the rise of $\frac{1}{20}$ inch, the pressure necessary to keep the valve open increases at least 5 lbs.

The safety valves of the locomotive should each be sufficient to discharge all the steam that the boiler is capable of generating; that is, they should be of sufficient capacity to discharge the steam as rapidly as it can be formed. At 140 lbs. pressure we have found that the amount of coal capable of being burned per hour is 1,855 pounds, or 0·517 pounds per second. The corresponding evaporation per second would be $\cdot 517 \times 6 \cdot 08 = 3 \cdot 143$ lbs. of water. The relative volume of steam at this pressure is 182·6, and multiplying by ·016, which may be taken as the volume of 1 lb. of water, there will be 2·92 cubic feet of steam for each pound of water evaporated. Hence, the maximum volume of steam which the safety valves should accommodate is $2 \cdot 92 \times 3 \cdot 14 = 9 \cdot 1688$ cubic feet per second. The theoretical velocity of steam flowing into the atmosphere, at this pressure, is about 1947 feet per second. The small area of safety valve actually used is much less than that given by either of Rankine's two rules, or by the rules of Bourne or Wilson, or even by the formula of efflux, $v = \sqrt{2gh}$.

Applying Mr. Bourne's formula, $a = A \cdot \frac{V}{300\,P}$, where A equals the area of the piston (in square feet?) = 1·39 square feet, V equals its velocity in feet per minute, = 2200 feet, and P equals the effective pressure, or, in this case, 140 lbs., we find the required area

to be 76·1 square inches. By Rankine's first rule, that the area a, in square inches = from $\frac{1}{25}$ to $\frac{1}{30}$ of the number of pounds of coal burned per hour, taking the smallest fraction, we obtain: $a = \frac{1}{30} \times 1855 = 61{\cdot}8$ square inches; and, by his second, that a in square inches = from $\frac{1}{150}$ to $\frac{1}{180}$ of the number of pounds of water actually evaporated per hour, also taking the smallest fraction, we obtain $a = \frac{1}{180} \times (1855 \times 6{\cdot}08) = 62{\cdot}6$ square inches. It is probable that these formulæ do not at all take into account the peculiar conditions in the locomotive boiler. Mr. Robert Wilson states a rule that the area $a = \frac{S}{W}$, where S equals the number of pounds of steam generated in one second, or 3·153 lbs., and W equals the weight of steam in pounds discharged per square inch of opening per second. The latter, according to Mr. McFarlane Gray, may be approximately represented by $W = \frac{P}{70}$, where P is the pressure in pounds per square inch above zero. Hence, $W = \frac{140}{70} = 2$, and $a = 1{\cdot}57$ square inches, as compared with ·2474 square inch the real effective area.

The size of safety valves in use upon locomotives has probably been fixed without any regard to the requirements of the immense rate of evaporation in their boilers, as compared with that of stationary boilers. It would seem to be only the constant attendance upon locomotive engines, and the constant watch upon the steam gauge, that prevent the generation of steam faster than it could be delivered by the valve, and a consequent over-pressure.

V. The Transmission Apparatus, or that by which the power in the steam is transmitted to the engine, may be regarded as including the throttle valve; the steam-pipe, consisting of the dry pipe in the boiler, and the branch pipes; and that by which the steam escapes into the atmosphere after doing its work in the cylinder, or the exhaust pipes and blast orifice. The construction of the former is shown in Figs. 12—15, Plate B, of the drawings, and in Figs. 90 and 91, Plate C. If the boiler pressure is reduced, as it usually is, 20 lbs. from its pressure of 140 lbs., by this apparatus, its efficiency would be represented as $\frac{140 - 20}{140} = {\cdot}857$, and this is caused by and varies as the density of the steam, the square of the piston speed

and of the ratio of the area of the piston to the cross-section of the steam pipe, and depends upon the bends and friction in the pipes. The latter varies directly as the density and square of the velocity of the steam, and inversely as the diameter of the pipe. The motion of steam, or its efflux into a fluid of less density, or the atmosphere, depends upon the difference of pressure. The effective pressure, or the excess above the atmospheric only, acts to produce the motion of steam through the steam pipes, and its efflux into the cylinder. In doing this it can do work represented by $V \cdot w \times h$, where V is the volume of steam in cubic feet, w the weight of a cubic foot, and h the distance through which it moves, which may always be considered as a height through which the weight Vw falls. If there was no resistance to the motion, from the bends and friction in the pipes, in falling through the height h, from a state of rest, the weight of steam $W = Vw$, would acquire a theoretic velocity of v feet per second, and the energy thus stored in it would be represented, as we have already seen, by the fundamental term in dynamics,

$\frac{1}{2} Mv^2 = \frac{1}{2} \frac{W}{g} \cdot v^2$. Now if there is no loss, these two quantities of work are equal, or $\frac{1}{2} \frac{Vw}{g} \cdot v^2 = Vw \cdot h$, $h = \frac{v^2}{2g}$, and $v = \sqrt{2\,gh}$.[1] On this simple formula all the theory of the efflux of fluids is based, for the quantity, h, is the height of a column of steam one inch square, that would be equivalent in weight to the pressure of the steam per square inch above the atmosphere, or $\frac{p}{w} \times 144$.[ii] Hence, to find the velocity with which steam of 100 lbs. effective pressure would escape into the atmosphere, we apply the formula

$v = C\sqrt{2\,gh} = C \times 8{\cdot}025 \sqrt{\frac{p}{w} \times 144}$. The pressure per square foot would be more exactly $100{\cdot}304 \times 144 = 14{,}443{\cdot}776$ lbs., the weight of a cubic foot of steam being at this pressure, $\cdot 26405$ lbs., the velocity would be $v = C \times 8{\cdot}025\sqrt{\frac{14{,}443{\cdot}78}{\cdot 26405}} = C \times 1928$ feet per second. The mean value of the coefficient of efflux C, which, as shown by Weisbach, is made up and is the product of two other co-

[1] The formula is thus proved by Weisbach.

[ii] D. K. Clark

efficients, a coefficient of velocity φ, and a coefficient of contraction a, may be taken at ·62. Hence, the velocity with which the steam would flow into the cylinder, when there is no back pressure above the atmosphere, would be $v = \cdot 62 \times 1928$[i] $= 1195$ feet per second. This velocity increases slowly with the pressure, and calculation shows how ample this immense velocity would be in the branch pipe, $4\frac{1}{2}$ inches in diameter, to keep up with any piston speed that can be produced in the locomotive. The resistance must be very great to reduce its velocity so that the pressure falls in the proportion stated. Probably the greater portion lies in the valve chest and steam passages, and from the wire-drawing of the steam by the valve. The disadvantageous custom of not fully opening the throttle valve when running, in the present practice of locomotive drivers, wire-draws the steam at the throttle valve, and greatly diminishes the efficiency of the transmission apparatus.

B. The Engine.—Having now ascertained the functions and mode of action, in one or two points, of the locomotive boiler, the consideration of the details of the mechanism lies before us. The remaining figures in the drawings, plates *A*, *B*, *C* and *D*, contain full details, it is believed, of every important part of this.

The fundamental ways by which a complete knowledge of the engine mechanism is to be found, are two.[ii] I. The action of the machine during parts of its period or cycle, by which we ascertain the laws which determine the internal efficiency of its parts; and II, its action during whole periods, or the relation between mean efforts and mean resistances, by which the actual efficiency is determined.

It will be necessary to here omit the discussion, by the first of these methods, of the engine mechanism in detail. Its treatment would involve a consideration equal to that of the boiler; but, useful and interesting as the field of inquiry thus opened is, the details of the mechanism are, by reason of their greater approach to perfection and efficiency, of secondary importance to those of the boiler, and do not require so careful a scrutiny.

The second of these methods will form the method of inquiry in Part II, and I shall here merely state the topics which, in my imperfect plan of treatment, remain.

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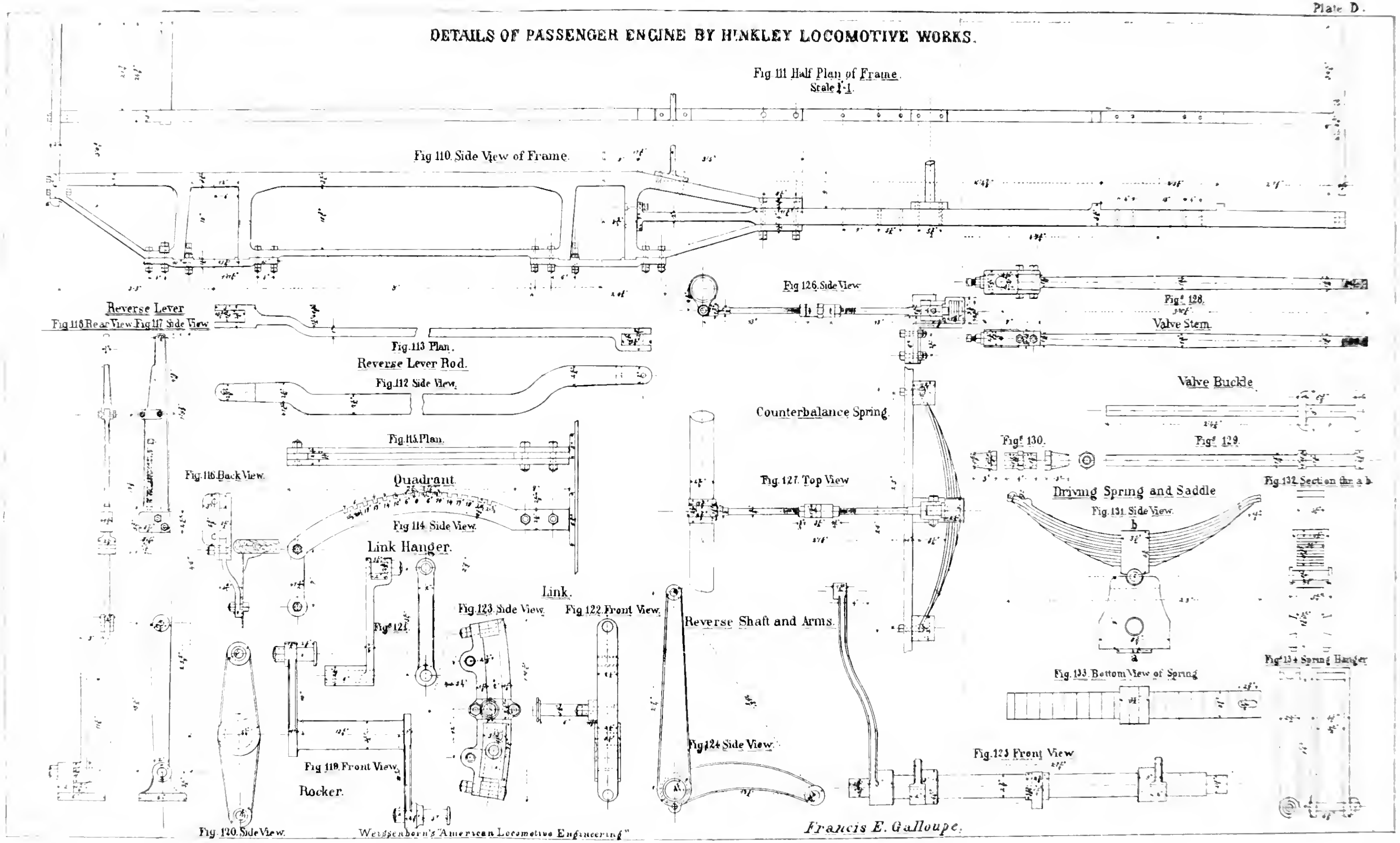
[i] Roper gives it 1875 feet, and D. K. Clark, 1957.

[ii] Rankine.

Plate D.



DETAILS OF PASSENGER ENGINE BY HINKLEY LOCOMOTIVE WORKS.
Fig 111 Half Plan of Frame.
Fig 110. Side View of Frame.
Reverse Lever
Fig 118 Rear View
Fig 117 Side View
Fig 113 Plan.
Reverse Lever Rod.
Fig 112 Side View.
Fig 115 Plan.
Fig 116 Back View.
Quadrant.
Fig 114 Side View.
Link Hanger.
Fig 121.
Link.
Fig 123 Side View.
Fig 122 Front View.
Fig 119 Front View.
Rocker.
Fig 120 Side View.
Fig 126 Side View.
Fig 128.
Valve Stem.
Counterbalance Spring.
Valve Buckle
Fig 130.
Fig 129.
Fig 127 Top View
Fig 132 Section thr. a b
Driving Spring and Saddle
Fig 131 Side View.
Reverse Shaft and Arms.
Fig 133 Bottom View of Spring
Fig 134 Spring Hanger
Fig 124 Side View.
Fig 125 Front View
Francis E. Galloupe.
Weissenborn's "American Locomotive Engineering"

I. *In the Cylinder*, the description of position, construction and parts—its heads, piston, packing, casing, the valve face, steam-chest, steam and exhaust passages—would be followed by a discussion of the reasons for its particular dimensions; what has determined its proportion, and its relation to other parts, to the boiler and driving wheels, the boiler power, tractive power, and to the steam expended in it, and the friction in it, and methods by which it is diminished by lubrication.

II. There would next be the description, office, and geometrical construction of the *Valve Gear*, the slide valve, rods, rockers, links, hangers, eccentrics, their disks, straps and rods: and the Reverse Apparatus, whose parts are the quadrant, reverse lever, rod, lifting links and counterbalance spring. The slide valve, in a single simple piece of mechanism, fills the office of admitting, cutting off, and releasing the steam in the cylinder, and of regulating the power to be developed by the entire engine. The lead, lap and travel of the valve, as affected and determined by the construction of the link, its action, and illustration by means of motion curves form one of the most important and interesting topics, in the locomotive engine.

III. *In the Action of the Steam in the Cylinder*, the best mode of treatment would be the discussion of actual steam indicator diagrams, for which purpose some fine indicator cards have been obtained. By these could be found, the differences from the assumed theoretic diagram, and the actual condition of the steam in the cylinder, its pressure, mean pressure, real point of cut-off, as distinguished from its apparent, the curve of its expansion, its release and compression, and the real occurrences in respect to condensation. The action and theory of blast pressure, the advantages and disadvantages of each of the two methods of producing an artificial draught for the furnace, the vacuum and plenum, and the effect of the former upon back pressure and the effective power of the engine, would have to be considered here, in connection with the cylinder.

IV. *The Transmission of Power to the Wheels*, relates to parts, such as the piston, cross-head, connecting-rod, and crank. There would be in succession considered, the efficiency of the crank, as a means of converting reciprocating into circular or rotary motion: the effect of the angularity of the connecting-rod, over that produced if there was harmonic motion only; the weight of the reciprocating

parts, their accelerations and retardations during the stroke, and at the dead-points, and the efficiency of the combination.

V. *The Running Gear* includes the wheels, shafts, journals, and framing to which they are attached. The locomotive would here be regarded as a carriage or vehicle for the boiler and mechanism, and the action of the wheels upon the rails, and of centrifugal force, which is partially counteracted, upon curves by the tractive pull, pointed out.

VI. *In the Balancing of the Engine*, would be considered the manner in which the weight is supported upon three points or a tripod, the driving wheels and centre pin of the truck, by means of the springs and equalizing levers; the means for preventing the zig-zag or lateral tendency of the motion to cause the flanges of the wheels to grind against the rails, arising from the alternate maximum force of the pressure upon the pistons upon each side of the engine; how this is affected by the gauge of the road: and how the weight of the reciprocating parts is balanced in the driving wheels.

All these relate to the engine alone, and doubtless other points would suggest themselves in the treatment of these.

VII. *The Tractive Power and Train Resistance* will be briefly considered in the following part.

Part II.—Trial of an American Passenger Locomotive.

By the kindness of Mr. Jno. Thompson, Master of Machinery of the Eastern Railroad Company, the opportunity was obtained of riding upon the engines of two of the fastest passenger trains of that road, and of taking therefrom data concerning the actual running of locomotives. The trains selected were the 2.15 P. M. Rockport train from Boston, which runs for a distance of 36 miles, and after a stop of 55 minutes at the terminus, makes a return trip to Boston; and the Bangor Express train, which leaves Boston at 8.30 A. M. The engine of this train runs to Portsmouth, N. H., 56 miles from Boston, is there detached, and 18 minutes after, with another train, makes a return trip to Boston. After obtaining information concerning the running of these engines, on Tuesday afternoon, March 14th, engine No. 36, "The John Howe," was taken, in order to

TABLE I.—Trip No. 1.

DATA AND RESULTS FROM HINKLEY ENGINE, No. 55, EASTERN R. R., ON 8.30 A. M. BANGOR TRAIN, DOWN TRIP.

Date: Wednesday, March 15th, 1876.
Day: Weather, dry and chilly; Temperature, 15°—40° Fah.; Wind, W., and very strong.

At Boston: *Coal in Tender at starting, 15 tubs, at 400 lbs., = 6000 lbs.* *Depth Water in Tender at starting, about 42 inches.* *Number of Cars, 5 Passenger, 1 Pullman, 1 Baggage, 1 Postal; Total, 8.*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Time Record.			Coal Record.			Speed Record.						Water and Steam Record.		Notes.
Miles from Boston.	Train Due. Time.	Station. Leave	Train Arrivals and Leavings. Corrected time by watch.	Length of Stop.	Steam Pressure. Gauge Readings.	Weight fired between stations.	Aggregate weight.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile	Oiling, Shutting Off, Braking, Stirring Fire, Air Brake Pressure, etc.
	H. M.		H. M. S.	M. S.	LBS.	LBS.	LBS.			LBS.						LBS.	
	A. M.		A. M.														
	8 30	Boston	8 30 34		137	13·5	13·5								2·079		Watch practically correct with railroad time, at 8.30 A.M.
			ar. 33 15														
		Prison Point	8 33 20	5		81·0	94·5		14					15·1	12·474	454·1	
		B. & M. R. R. Crossing.	8 35 40	...	138												
2		Somerville	8 37 05			27·0	121·5		21⅛ 20½						4·158		
		Curve at Somerville	8 38 30			67·0	189·0	61	19 17 14					26·6	10·395	907·9	
3		Everett	8 40 45		124	40·5	229·5	68	10						6·237		
			ar. 43 50											38·7		194·6	
5	8 42	Chelsea	8 44 15	25	139	101·3	330·8	20	10						15·600		Took 50 seconds to stop after brake was put on. Oiled cylinders from cab.
														14·1		973·4	
6		Revere	8 48 30		130	67·5	398·3	101							10·395		
		Oak Island.	8 51 50		115	141·8	540·1		10					32·4	21·837	502·8	Reading of Westinghouse Air Brake Gauge, 100 lbs.
10		West Lynn	8 55 55†		114	13·5	553·6	53							2·079		
			ar. 57 20†											42·3†		129·7	Engine clock 50 seconds slow, by watch.
11	8 59	Lynn	9 0 30	3 10	134	13·5	688·6	14	10						20·790		
														16·7		1297·3	
12		Swampscott.	9 04 05		123½	94·5	783·1	135							14·553		Throttle one-half open.
			ar. 10 50		126									35·6		227·0	Oiled cylinders.
16	9 12	Salem	9 13 15	2 25	133	81·0	864·1	27							12·474		
		Know-nothing	9 15 10													389·2	
			ar. 20 15		118									17·1	62·869		Very heavy up-grade, 43 ft. to one mile. Oiled cylinders.
18	9 20	Beverly	9 20 50	35	127	148·5	1012·6	41	10							1961·5	
			ar. 27 45							125	150	2454	27·9	17·3	14·553		
20	9 26	*North Beverly	9 28 05	20	130	94·5	1107·1	74	14							453·5	At 9.32 reverse lever was put in full forward gear. 10 secs. later the brake was put on, and full stop was made at 9.32 45.
			ar. 32 45						10	123	160	2618	29·8	25·1	33·204		
22	9 32	Wenham	9 33 25	40	123	216·0	1323·1	48								415·2	
					122				10	123	192	3141	35·7		5·387	112·1	Safety valve blowing. Throttle one-half open. Took in water.
27	9 43	Ipswich	9 46 25	...	137½	94·5	1417·6		10					21·6			
									10	114	240	3927	44·6		7·313		Depth before filling, 16 in.; after filling, 41¼ in.
30	9 50	*Rowley	9 54 45		114	128·3	1545·9	32	10					27·7		114·1	Speed taken at bridge.
									10	110	150	2454	27·9		9·234		
34		*Knight's Crossing	10 3 25			162·0	1707·9	32	10					16·9			
		Know-nothing	10 12 20	...												192·1	
37	10 05	Newberryport	10 14 00	...	143	121·5	1829·4	54						22·5	6·926		Valve blowing. Oiled cylinders.
									10	124	192	3141	35·7				
39		*Salisbury							10								
																86·4	
42	10 20	*Seabrook	10 25 05		132	81·0	1910·4	24	10								
														14·1	4·617		
43	10 25	*Hampton Falls	10 29 20		136	175·5	2085·9	81								288·1	
														24·5	10·004	208·1	
46	10 33	Hampton	10 36 40	...	120	216·0	2301·9	59									
														24·8	12·312	256·1	Heavy up-grade, about 43 feet to 1 mile.
49	10 40	North Hampton	10 43 55	...	110	189·0	2490·9	72	14						10·773		
									14	102	140	2290	26·0	17·1		376·1	Heavy up-grade. Pressure in air brake receiver fell from 76 lbs. to 40 lbs. in stopping the train, with the brake pumping. Stirred fire six times after leaving Boston.
51	10 47	*Greenland	10 50 55		120	243·0	2733·9	95	10						13·851		
							Tot. for 56 miles run.									172.8	
									10	111	200	3273	37·2	29·8			Depth water in tender before filling, 31¼ in.
56	10 57	Arrive at Portsmouth	11 01 00		125			40	10	111	220	3600	40·9				Depth water in tender after filling, 40¼ in.
			Average steam pressure, 127 lb.			Av. lb. coal per mile,		56						Average, 23·5	Average,	460·5	

* Flag Stations. † Time doubtful.

TABLE II.—Trip No. 2.

DATA AND RESULTS FROM HINKLEY ENGINE No. 55, EASTERN R R., ON BANGOR TRAIN, RETURN TRIP.

Date: Wednesday, March 15th, 1876.
Day: Weather, dry and chilly; Temperature 15°—40° Fahr.; Wind, W., and very strong.

At Portsmouth: Coal taken on, ... Depth Water in Tender at starting, 40¼ inches. Number of Cars, 7.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Time Record.			Coal Record.			Speed Record.						Water and Steam Record.		NOTES.
Miles from Portsmouth.	Train Due. Time. H. M.	Station. Leave	Train Arrivals and Leavings. Corrected time by watch. H. M. S.	Length of Stop. M. S.	Steam Pressure. Gauge Readings. LBS.	Weight fired between stations. LBS.	Aggregate weight. LBS.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed. LBS.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile LBS.	Oiling, Shutting Off, Braking, Stirring Fire, Air Brake Pressure, etc.
	A. M.		A. M.														
	11 18	Portsmouth	11 26 35		137	81·0† 283 5	364·5		14						39·731		† Six shovelfuls, or 81 lbs. of coal were put in before leaving Portsmouth. Coal wet before starting.
									10	95	160	2618	29 8	22·5		495·8	
5	11 28	*Greenland.	11 39 55		94	141·8	506·3	73	10	93	180	2945	33 5		15 456		Stirred fire.
			....		....				.....	....	.....	.....	....	17·3		482·2	
7	11 35	North Hampton	11 46 50	...	94	135 0	641·3	71							14 715		
			....		.. ..				10	114	200	3273	37 2	30 0		306 1	Oiled cylinders. Stirred fire.
10	11 42	Hampton	11 52 50	...	127	54 0	695·3	45	10						5·886		
									.....	....	.....	.....	....	37·9		122 4	
13	11 47	*Hampton Falls	11 57 35		128	148 5	843 8	18							16·187		
			P. M.						.....	....	.....	.....	....	12·0		1010·1	
14	11 50	*Seabrook	12 02 35		128	175 5	1019·3	149	10	119	130†	2127	24·2		19 130		† Heavy up-grade.
									10	104	240†	3927	44 6	28·8		397·9	† Up-grade. Air brake pressure fell from 85 to 50 lbs. in stopping the train.
17	P. M.	*Salisbury..	12 08 50			40 5	1059 8	59	10	102	220	3600	40 9		4·415		
			ar. 12 50		....				.....	....	.....	.....	....	30 0		137·7	Stirred fire.
19	12 05	Newburyport	12 14 50	2 00	133	94 5	1154 3	20							10·301		
		Know-nothing	... ...	...	....	108 0	1262 3		.....	....	.....	.....	....	14 2	21·772	667·1	
22		*Knight's Crossing	12 27 30		117	148 5	1410·8	68	10						16·187		
									10	110	220	3600	40 9			252 6	Oiled cylinders.
26		*Rowley	12 ... 05		122	2[illegible]9·5	1640 3	37							25·016		
			ar. 34 15		118				.....	....	.....	...	....			520 3	Stir'd fire. Safe. valve began to blow off at 142 lb.
29	12 28	Ipswich	12 40 40	6 25	134	195·8	1836·1	77	10						30 741		At Ipswich, Depth water in tender, before filling, 17¼ in. after filling, 42 in.
			....		....				10	97	150	2454	27·9	25 7		383·7	
34	12 40	Wenham	12 52 20	...	103	54 0	1890 1	39	10						8·478		Stirred fire.
									10	102	170	2781	31 6	27 7		264 5	Up-grade.
36		*North Beverly	12 56 40		98	67 5	1957 6	27	10						10·598		
			....		....				10	100	220	3600	40·9	25·7		330·1	Oiled cylinders.
38	12 48	Beverly	1 01 20	...	118	54 5	2011·6	34							8·557		
		Know-nothing	... ...	...	....	40 5	2052·1		.....	....	.....	.....	....	19 1	6 359	465·4	Stirred fire.
			ar. 07 35		124												
40	12 58	Salem	1 09 00	1 25	143†	216 0	2268 1	128	10						33 912		† Valve blowing.
														31·3			
44		Swampscott	1 16 40		99	00·0		54	10						....	423 1	
			ar. 19 15		118				10	98	200	3273	37·2	23·2			
45	1 11	Lynn	1 20 00	45	128	40 5	2308 6	00							6·359		Oiled cylinders.
									.....	....	.....	.....	....	12 7		396 8	
46		West Lynn..	1 23 25		114	114 8	2423·4	41	10						18·024		Stirred fire.
									.....	....	.....	.....	....				
		Oak Island	1 27 30		98	00 0			10					30·5		281·1	
									.....	....	.....	.....	....				
50		Revere	1 31 15		98	67 5	2490·9	29	10						10·598		
			ar. 35 15		.....				.....	....	.....	.....	....	12·9		661·3	
51	1 28	Chelsea	1 35 55	40	113	40 5	2531·4	68							6·359		
									.....	....	.....	.....	....	32·7		192·4	
53		Everett	1 39 35		104	13·5	2544 9	20							2·120		
									.....	....	.....	.....	....				
		Curve at Somerville	1 41 55		100	00 0								14·7		132·3	
			ar. 43 40		....												Stirred fire.
54		Somerville	1 44 00	20	101	27 0	2571 9	14							4·239		
		B. & M. R. R. Crossing					Tot. for 56 miles run.										
		Prison Point	.... 1 46 35	...	 110				.....	....	.....	.....	....	22·8		132·3	
56	1 45	Arrive at Boston	1 49 15		110												Took 35 seconds to stop at Boston. Depth water in tender on arrival, 23¼ inches. Watch 15 secs. fast by standard time at 1.55 P.M.
		Average steam pressure,			115 lb.	Av. lb. coal per mile,		55					Average,	23 6	Average,	383 6	

* Flag Stations.

TABLE III.—Trip No. 3.

DATA AND RESULTS FROM HINKLEY ENGINE, No. 55, EASTERN R. R., ON 8.30 A. M. BANGOR TRAIN, DOWN TRIP.

Date: Thursday, March 16th, 1876.
Day: Weather, dry and pleasant; Temperature, 40° Fah.; Wind, W., breeze.

At Boston: *Coal in Tender at starting, 14 tubs, at 400 lbs., = 5600 lbs.* *Depth Water in Tender at starting, about 40 inches.* *Number of Cars, 5 Passenger, 1 Pullman, 1 Baggage, 1 Postal; Total, 8.*

1	2		3	4			5		6	7	8	9	10	11	12	13	14	15	16	17	18
				TIME RECORD.						COAL RECORD.			SPEED RECORD.						WATER AND STEAM RECORD.		NOTES.
Miles from Boston.	Train Due Time.		STATION.	Train Arrivals and Leavings. Corrected time by watch.			Length of Stop.		Steam Pressure. Gauge Readings.	Weight fired between stations.	Aggregate weight.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile	Oiling, Shutting Off, Braking, Stirring Fire, Air Brake Pressure, etc.
	H.	M.	Leave	H.	M.	S.	M.	S.	LBS.	LBS.	LBS.			LBS.						LBS.	
	A.	M.		A. M.																	
	8	30	Boston	8	31	00			132	00·0	00·0		10								Watch practically correct at 8.30 A.M.
				.....	...	...			....				......	....	......	......	....				Oiled cylinders.
			Prison Point	8	33	40		...	131	40·5	40·5		21⅛								
				.....	..	...			....									17·8	6·845	213·5	
			B. & M. R. R. Crossing.	8	36	15		...	130	00·0	40·5		10								
2			Somerville	8	34	45			123	27·0	67·5								4·563		
													......	....	.... .	......	....				
			Curve at Somerville	8	39	00			122	81·0	148·5	34						17·1	13·689	1138·9	
													......	....	......	......	....				
3			Everett	8	41	15			119	40·5	189 0	81	10	118	200	3273	37·2		6·845		
				.....	...	...			....				21⅛	127	180	2945	33·5	36·7		213·5	Stirred fire.
5	8	42	Chelsea	8	44	30		..	132	94·5	283·5	20	10						15·971		
													10	....	160	2618	29·8†	13·6		996·6	† Taken at 8.47.25, and counted till 48.55.
6			Revere	8	48	55			127	94·5	378·0	95	10						15·971		
													10	....	200	3273	37·2†				† At 51.00.
			Oak Island.	8	51	50			126	81·0	459·0		10					32·7	13·689	462·7	
													10	127	220	3600	40·9†				† At 54.00
10			West Lynn	8	56	15			128	00·0	459·0	44	......	128	120	1963	24·1†				† At curve, 54.45.
				ar.	58	25			138†				14	....	......	......	....	27·7		....	† Valve blowing off. Stirred fire.
11	8	59	Lynn	9	00	00	1	35	139	47·3	506·3	00	10						7·994		Damper open in fire-box door.
													10	....	160	2618	29·8	16·0		498·8	
12			Swampscott	9	03	45			128	94·5	600·8	47	10						15·971		Oiled cylinders.
				ar.	10	15			134				10	127	220	3600	40·9†	36·7		249·0	† Time, at 9.06.00.
16	9	12	Salem	9	13	00	2	45	133†	67·5	668·3	24	6	125	240	3927	44·6†		11·408		† Valve stopped blowing off. † Time, at 9.07.15.
				ar.	15	50			135				21⅛								
			Know-nothing	9	16	15		25	136				14					15·8		355·9	
				ar.	20	35			138†				10	128	140	2290	26·0†				† Time, 9.18. Stirred fire.
18	9	20	Beverly	9	21	15		40	136†	67 5	735·8	34	10						11·408		† Valve blowing.
													10	133	160	2618	29·8†	18·0		355·9	† Heavy up-grade. Time, 9.23.00.
20	9	26	*North Beverly	9	27	55			134	54·0	789·8	·4	10	132	150	2454	27·9†		9·126		† Time, 24.20.
				.....	...	...							10	129	80	1309	14·9†	22·8		284·7	† Level. Time, 26.00. Stirred fire.
22	9	32	Wenham	9	33	10		...	137†	135·0	924·8	27	6	126	180	2945	33·5†		22·815		† Valve blowing. † Time. 9.30.00. Stirred fire.
				ar.	42	40			....				6	128	260	4255	48·4†	31·6		284·7	† Time, 9.38.00 Took on water. [after, 42¾ in.
27	9	43	Ipswich	9	46	05	3	25	135	162·0	1086·8	27	6	124	230	3764	42·8†		20 088		† Time, 9.41.00. Depth before filling, 20 in.;
													10	123	240	3927	44·6†	25·3		417·8	† Time, 9.49.00.
30	9	50	*Rowley	9	53	10			130	121·5	1208·3	54	10	12)	240	3927	44·6†		15·066		† Time. 9.50.00. Stirred fire.
													10	126	190	3108	35·3†	36·0		235·1	† Up-grade. Time, 9.56.00.
34			*Knight's Crossing	9	59	50			120	54·0	1262·3	30	10	124	204	3338	37·9†		6·696		† Time, 9.58.00.
				.....	...	...							10	119	220	3600	40·9†				† Time, 10.01.00.
			Know-nothing	10	03	10		...	133	67·5	1329·8		10					17·8	8·370	313·2	Oiled cylinders.
				.....	...	...			....												At Newburyport, depth water in tender, 36 in.
37	10	05	Newburyport	10	09	55		...	141	54·0	1383·8	41	14						6·696		
													10	126	200	3273	37·2†	25·7		208·9	† Time, 10.13.00. Stirred fire.
39			*Salisbury	10	14	35			124	135·0	1518·8	27	10						16·740		
													10	121	190	3108	35 3†	28·3		348·2	† Time, 10.16.00.
42	10	20	*Seabrook	10	20	55			133	40·5	1559·3	45	10	124	180	2945	33·5†		5·022		† Up-grade. Time, 18.00.
													10	122	160	2618	29·8†	14·4		313 4	† Time, 10 23.00. Stirred fire. No stop made.
43	10	25	*Hampton Falls	10	25	05			122	67·5	1626·8	41							8·370		
				ar.	30	25			135†				10	117	120	1963	24·1†	33·6		174·1	† Very heavy up-grade. Time, 10.27.00.
46	10	33	Hampton	10	33	10	2	55	138	27·0	1653·8	23	14						3·348		† Valve began to blow off at 144½ lbs., while at
				ar.	39	25			....				......	....	......	......	....	24·8		69·6	Stirred fire. [station.
49	10	40	North Hampton	10	40	25	1	00	138	40·5	1694·3	9	10						5·022		Stirred fire.
				ar	47	10							10	138	156	2552	29·0†	16·9		156·7	† Up-grade. Time, 10.42.30
51	10	47	*Greenland	10	47	30		20	....	229·5	1923·8	20	10	120	160	2618	29·8†		28·458		† Time, 10.49.00. Stirred fire.
											Tot. for 56 miles ruu.										
			Arrive at										10	118	220	3600	40·9†	29·3		355·1	† Time, 10.50.00. Stirred fire. [from full speed.
56	10	57	Portsmouth	10	57	45			118			46	10	110	240	3927	44·6†				Up-grade. † Time, 10 52.00. Took 40 secs. to stop
									Average steam pressure, 131 lb.		Av. lb. coal per mile,	41						Average, 24·5		Average, 364·1	Depth water in tender {before filling, 27 in. after filling, 42 in.

* Flag Stations.

become practically acquainted with the daily operation of the locomotive.

After setting my watch carefully by the railroad time, making out a table with blank columns for data, measuring the diameter of the driving wheels and pump plunger, taking the depth of water in the tender, obtaining an estimate of the amount of coal aboard, and the capacity of the tank, and noting the weather, condition of the rails, direction of the wind, the steam gauge, the numbers on the cut-off notches of the reverse quadrant, and the number of cars, we started. Mounted upon the fireman's seat, the engine rode much easier than was expected, and, except at the greater speeds, little difficulty was experienced in writing.

At the higher speeds even, from five to six revolutions, or ninety-eight feet per second,—the momentum of the engine carried it lightly over the slight inequalities in the rails, and it was very rarely that much thumping or pounding occurred.

Upon the three succeeding days, trips were made to Portsmouth and return upon engine No. 55, which was built at the Hinkley Works in October, 1875, and is the same engine the details of which have been given, and parts discussed in Part I.

Upon these trips records of the time were taken, as accurately as possible, at which the engine passed each station, of the steam pressure, the cut-off notch, and the amount of coal thrown into the fire-box, and although the stations came rather close together in respect to time, when not employed in any other direction, the speed was usually taken by counting the oscillations of the cross-head.

In brief, the aim was to jot down every occurrence that took place in regard to the engine.

The accompanying tables show the data taken, and the results obtained.

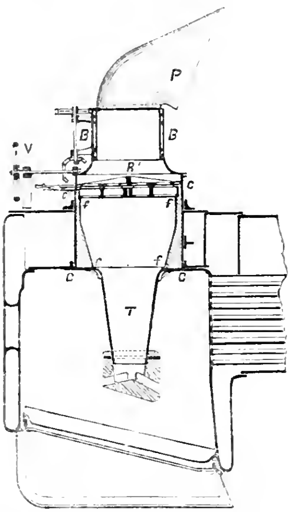
The carrying of a train from Boston to Portsmouth means so many gallons of water and pounds of coal consumed. These tables state approximately what these amounts are. They show, so far as no exceptional conditions exist, primarily, the facts concerning the actual manner in which the best locomotives are at the present time run. From these data are furnished us the means whereby we may calculate other circumstances in regard to locomotive power and resistances, which have their influence in determining its actual efficiency.

(To be continued.)

CONSUMING SMOKE IN FURNACE OF LOCOMOTIVE ENGINE.

[From the *Engineer*, London, Dec. 15th, 1876.]

We illustrate in the accompanying engraving a very curious arrangement for consuming smoke in locomotives, used with great success on the Constantinople and Adrianople section of the railways of European Turkey. The device has been patented by Herr v. Reimherr, locomotive superintendent of the line; it will be seen at a glance that a wind-cowl directs a strong current, when the engine is running, on the fire. The apparatus is characterized by the two following features:—Natural injection, the progressive motion of the locomotive, occasioning a certain quantity of hot air to spread evenly over the fire. Introduction of an iron plate cylinder between the crown of the fire-box and the outer shell of the boiler, which relieves the crown-plate of about one-third of the pressure which it generally bears. The manner in which the smoke-consumer, constructed according to those principles, may be applied to a new, as well as to already existing locomotives, will be easily understood from the adjoined drawings and the following description:—*c c* is the iron plate cylinder which unites the fire-box-crown with the boiler-shell, and relieves the former of a part of the pressure; this cylinder is open at top and bottom; *f f*, cast iron cylindro-conical tube placed inside of cylinder *c c*; the empty space round these two is to be filled with fire-clay, to prevent the cooling of cylinder *c c*; *T*, conical cast iron tube, resting with its upper flange on the lower bearing of tube *f f*; an air distributor, made of fire-clay, is fixed to lower end of the conical tube *T*; *R'* is a register valve for regulating the admission of cold air; *B*, cast iron mantle; *P*, bell-mouthed air catcher, which can be turned and fixed in all positions by a gearing of tooth-wheels and bevel-wheels worked by the small hand-wheel *V*. The self-progressive motion of the locomotive forces the air into the air-catcher *P*, whose mouth must always be turned in the direction of the motion of the engine. The air, heated by its



contact with the cylindro-conical tube *f f* and the cone *T*, escapes through the channels in the fire-clay air-distributor, being evenly dispersed over the surface of the burning fuel, and at a sufficiently elevated temperature to produce a complete combustion.

The apparatus has been fitted to a six-wheeled all coupled goods engine, weighing thirty-six tons. The wheels are all between the fire-box and the smoke-box. The fuel used is Cardiff and Newcastle coal mixed, and the consumption on passenger trains equaled 11 to 12 kilos. per millimetre. The apparatus has been at work since May, and saves a large proportion of fuel, besides completely preventing smoke. Between Constantinople and Adrianople the country rises twice, necessitating inclines of 1 in 60; ordinary locomotives, therefore, have to work hard, and the increased draft used to fill the smoke-box with unburned particles of coal. Since the application of Herr Reimherr's apparatus the smoke-box remains almost empty, and all the coal formerly carried into it unburned is saved. The trains do not go faster than about 18 miles an hour; it is therefore supposed that the apparatus with express engines would act much more vigorously.

Cost of Railway Improvements in Europe.—In the *Builder*, London, November 18, 1876, there is a compilation of the directors' reports of expenditures on the Midland Railway, for the period of five years, ending June last, which shows the process of aggregation of capital in conjunction with a thriving and growing railway system *after the completion* of the main stem of the lines. It is shown that, in their original construction, the capacity of the "lines open for traffic" was very far short of the actual requirements for traffic purposes; and in further land purchases, duplicating lines, making new sidings, extending the station and warehouse accommodation, and generally improving the carrying capacity of the line, an enormous amount has been expended, the lines having been only gradually brought up to their present state of efficiency. The gross outlay under this head, has been for land, compensation, construction of way and stations, £5,100,000; for Law and Parliamentary charges, £133,000; for Block Telegraph, £37,000, making a total of £5,270,000. The additions made in this way to the original cost have been at the rate of about £1,050,000 per annum, or on the mean "open" mileage not less than £5,000 per mile in the period of five years. In other words, the property has been, in five years, improved at a cost almost equiv-

alent to the construction of an additional single line throughout the entire system. On referring to the last issued report, we find also the expenditure of this character is by no means exhausted, for in the current half year, £821,000 were to be laid out in providing increased station accommodations, sidings, engine sheds, work-shops, etc., on the lines already open for traffic; and even afterwards the known necessities of the lines would take £849,000 further to meet them. The whole of this additional outlay has already received the sanction of the proprietors.

It is shown also under the head of the expenditure upon the construction of new lines, that spread over a lengthened period, and embracing a vast number of new lines variously situated, this branch of the expenditure throws some light on the relative cost of (1) land, and compensation paid for property taken over by the company; (2) the construction of the lines, including structures, signals, rails, etc.; and (3) the by no means inconsiderable amount represented by legal and Parliamentary costs, including conveyancing, etc. The proportion of the cost attributable to each of these distinct heads would appear to be:

Land and compensation, ...	11	per cent.
Construction, including rails, etc., . .	88	"
Law and Parliamentary, ...	1	"
	100	

The gross outlay under this head, it would appear, has been £4,892,000, for which about 200 miles of new line have been added to the Midland system, the cost being equal to about £25,000 per mile. The further expenditure under this head will be no less than £3,500,000, to complete the 122 miles wholly, and 49 miles partly, owned by the company, and still under construction or to be constructed.

The further heads of expenditure during the five years comprise £2,336,000 for new rolling stock, and a similar amount subscribed to other connecting lines in which the Midland company is interested. For the latter object £1,000,000 further will be subscribed in the current and future half years.

It will thus be seen that the company has been laying out £3,000,000 per year for some years back, and we may believe that it has been judiciously applied, judging from the high dividend position the company has been able to maintain concurrent with this enormous expenditure.

THE LATEST ARMOR PLATE EXPERIMENTS AT SPEZIA.

[From the *Iron Age*, New York, February 8th, 1877.]

A recent number of the London *Times* has an interesting account of some of the Italian experiments at Spezia, conducted during the month of December. The experiments at Spezia were temporarily suspended, because some of the targets had not arrived. The series has since been continued and brought to an end by the complete destruction one after another of all targets opposed to the 100 ton gun. This was only to be expected after the proofs given during the earlier trials that gun and carriage were more than equal to the task set before them. But the latter series of experiments has been so interesting on account of the variety of the targets and the use of reduced charges in some cases, that we are glad to have the opportunity of presenting the results to our readers.

It will be remembered that during the first series 42 rounds had been fired with various charges, but all exceeding the guarantee of the manufacturers, and that, in some cases, the guarantee was so overpassed that the Italian government declared themselves satisfied, and accepted the gun, so that they might make the best use of the experiments, by trying different charges of different kinds of powder. The powder used throughout the second series, was that manufactured expressly by the Italians, and called "progressive powder of Fossano." The result has been highly satisfactory to the scientific designers of the powder, for, though a considerable quantity of it has to be used to give a certain velocity, high velocities can be obtained with a very moderate pressure on the interior of the gun. The manufacture of the Fossano powder is peculiar. After passing through the first stages of manufacture, and being brought to the condition of "meal powder," it is pressed into cakes, which have a density of 1·79. The cake is then broken up into irregular grains of about $\frac{1}{8}$ to $\frac{1}{4}$ in. in thickness. The grains are then mixed with a certain quantity of fine grain powder, and the whole mass is pressed into a cake which has a density of 1·776. This second cake is then broken up into tolerably regular pieces, about $2\frac{1}{8}$ in. square by $1\frac{3}{4}$ in. thick. These grains, if they can so be called, are therefore composed of a number of small pieces with a higher density, placed like

the raisins in a plum-pudding, in a sort of conglomerated powder material of a lower density. The intention of the inventors of this powder was to bring about a condition of affairs in which more gas would be produced in a given time when the powder has been partly burnt, than at the commencement of its ignition.

On the 14th of December, the first round of the new series or 43d round from the 100 ton gun was fired with a charge of 240 lbs. of Fossano progressive powder, and the usual 2000 lb. Palliser shell against the Cammell sandwich target, which presents a front 12 in. plate, then 12 in. of wood, with iron stringers, and behind that a 10 in. plate. This charge was a very small one, and gave a velocity of only 1050 feet per second. The object of the committee was to find the actual penetration of different forms of targets, under conditions which would prevent the complete penetration of the structure, for the previous experiment had shown that to fire the full charges would in every case be the ruin of the target and prevent anything like judgment of comparative results as far as penetration was concerned. The shell passed through the first plate and cracked it through from top to bottom, passed through the wooden interior, and entered 6·8 in. into the second plate. The base of the shell broke up and the remainder was starred. Judging from past experiments with gun cotton shells, the Italian committee consider that had this shell been loaded it would have completely blown off the front plate. As it was, the skin of the ship was cracked and a vertical iron beam behind was considerably doubled up.

The gun was then loaded for the 44th round, the charge and projectile being precisely similar to those used in the preceding round. This time the target was of the same dimensions as that used in the old experiments, but with a Brown's solid plate 22 in. thick. The sea was rough, and the pontoon moved visibly after the gun was laid, so that the shell, instead of striking the point aimed at, hit the plate on its lower edge and broke into several pieces, which were deflected downward and made a hole in the ground about 6 ft. or 8 ft. deep in a slanting direction under the target. Though lost for the immediate object of the experiment, this round was of great interest, for it showed that a shell striking the edge of the narrow belt of armor, which will soon be all that ships can afford to carry, will tear through the bottom of the vessel with force enough to pierce engine-rooms and boilers, and pass out below the water line on the other side.

Round 45 had been looked forward to with great interest. Previous experiments with guns of smaller calibre had given reason to believe that a plate of chilled cast iron, by presenting an extremely hard surface to the point of the projectile, might break it and so prevent its penetration. The charge was 400 lbs. of Fossano powder, and gave a velocity of 1494 ft. to the 2000 lb. shell, just equal to the effect of a charge of 341 lbs. English powder. The target had 8 in. plate in front, then a strong layer of wood, and behind this a 14 in. plate of chilled iron from the Gregorini Works, near Como.

This Gregorini cast iron deserves a word of praise. It is really of splendid quality, being very hard, with a tensile strength of from 16 to 17 tons per inch. Ordinary cast iron usually fails at about half that strain, and very rarely rises as high as 10 or 12 tons. Indeed, so good is it that the Italian artillery of the land service have succeeded in producing heavy cast iron rifled guns far superior in strength to anything that has ever been known in England. But it was not able to resist the shell from the 100 ton gun, which penetrated the target completely and caused a more terrible ruin behind than had occurred in any previous experiment. The shell was broken up into many pieces, which dashed through into the interior of the ship, carrying with them a great number of ragged fragments of broken plate, and causing such a hail of iron that nothing could have lived between decks. The sand bags behind were deeply pitted with many hundreds of pieces, and the experiment clearly proved that the old fault of cast metal still exists, namely, that when it breaks under the influence of a heavy blow, it is dashed to atoms.

In round 46 the shell broke up in the gun, but round 47 was fired under the same conditions as No. 45, and the iron plates were similar in kind and dimensions—only in this case the front wrought iron plate was placed immediately upon the cast iron in rear; the wood coming behind both; again the target was completely penetrated and ruined, a large portion of the front plate being at the same time torn off. In these two remarkable rounds (45 and 47) not only were the fragments of the cast iron plate driven forward, but also out of the sides of the targets. Again, nothing could have lived behind the target, so terrible was the hail of iron fragments caused in round 47, the velocity of the shot being 1502 ft.

After the failure of striking the right spot, which occurred in round 44, on account of the motion of the pontoon, and therefore of

the gun, the apparatus for firing was transferred to the deck of the pontoon, and an arrangement made by which the officer, whose duty it was to touch the button which, by the action of electricity, carried flame to the powder, could himself run the piece and discharge it at the right moment. This was a near approach to what would actually happen on board ship, and the result was, that in every succeeding round the white mark painted on the target, was obliterated by the shot, which always struck on the right place.

The combinations of iron and wood, wherein the iron was in two layers, having thus been destroyed, the target carrying the 22 in. solid Brown's plate was again subjected to attack. Round 48 was fired with a reduced charge of 240 lbs., similar to that used in round 43. The velocity was 1062 ft., and the point aimed at was near the left of the target. The shell broke up the front part, remaining in the hole, having penetrated about 15·6 in. If we compare this effect with round 43 against the sandwich target, we shall see that the solid Brown's plate had by far the best of it; for while the projectile fired at the sandwich target with a velocity of 1050 ft. penetrated nearly 31 in., of which 19 in. was through iron, that fired at the Brown's plate penetrated only 15·6 in. of iron and no wood. Taken in conjunction with the possible use of gun cotton shells, this round would appear to establish conclusively the fact, that targets composed of moderately thick iron plates, placed in layers alternating with wood, such as that now under trial at Shoeburyness, do not all approach in strength the same thickness of iron disposed in one solid plate on the front of the structure. Round 49 was fired with 180 kilog. (400 lbs.) of progressive powder, representing what is for the present the full service charge of the 100 ton gun. The velocity of the projectile was 1499 ft., and it was aimed at a part of the target near the right of the plate. A large portion of the plate was torn off, the target was completely penetrated, and the rear of it so ruined as to be incapable of repair; but the hail of fragments behind was not so terrible as in the case of the target backed by cast iron.

The gun was loaded for round No. 50, but with a charge calculated just to penetrate the Brown's solid plates—namely, 264 lbs. of English powder. The velocity given to the projectile was 1299 ft., and it was aimed full in the centre of the Brown's plate. The effect was as anticipated. The shell just passed through the plate, of which it tore off a large fragment, splitting the plate from top to bottom. The

backing was not pierced. The verdict of every one was that Brown's wrought iron plate had proved itself to be of magnificent quality, as it gave a high resistance to penetration with a minimum of brittleness, but it could not be expected to keep out a 2000 lbs. shell, fired with a velocity of 1500 ft.

The Working of the Mississippi Jetties.—New Orleans papers continue to bring evidence of the success of Captain Eads' engineering in the mouth of the Mississippi. The *Picayune* says: We learn, that for some time past the channel between the jetties at the South Pass is everywhere more than 200 feet wide, for a depth of 20 feet at average flood tide, and that in the middle of this wide channel the depth is more than 22 feet. This is equal to from $22\frac{1}{2}$ to 23 feet at the highest tide at South Pass, when a range of three feet tide, with a channel depth of $19\frac{1}{2}$ feet, for from 80 to 100 feet in width, is usually reported at Southwest Pass. Therefore it will be seen that the jetties have given, though yet in an incomplete state, a magnificent channel across the South Pass bar to sea, twice as wide and several feet deeper than has ever been obtained across the Southwest Pass bar. All through South Pass, from its head to the jettied channel over the bar, as is generally known, the depth exceeds 30 feet for more than 200 feet in width.

We are informed that the works required to confine the flow of water from the main river, above the common head of the passes, into South Pass, so as to secure a like deep channel entrance to South Pass over the river middle-ground shoal about its head, are being energetically prosecuted with every prospect of early success. Already, notwithstanding the low stage of the river, the one-dipper dredge boat at work there to expedite the cutting out of a deep channel entrance, has succeeded, as we are assured, in obtaining a depth of inlet of from 20 to 22 feet across this choal, which the tidal current suffices to maintain and widen. Soon, we are told, two more powerful dredges will be put to work there, and with three boats working together, an entrance channel across this hard sand middle-ground shoal, of sufficient width and depth for the largest class of ocean steamers, even at the present low river stage, may be expected at an early date. With the river at the height it was three months ago, we would have, even now, a clear and unobstructed channel of more than 22 feet in depth, from New Orleans to the sea, through South Pass.

FRICTION OF PLAIN SLIDE VALVES.

By John W. Hill, M. E.

[From the *Engineering and Mining Journal*, February 3, 1877.]

Several months ago the writer, in the routine of duty as a contributor to a Western mechanical journal, furnished for publication an article under the above head. The paper had for its purpose an exposition of the true relative power expended in moving the ordinary slide valve of steam engines, with such hints upon the construction as would aid designers in reducing the loss of power by friction of the valve to a minimum. Since its original publication, the article has been reproduced in other papers, and variously commented upon. The vigor and pertinacity with which the writer's conclusions upon this topic have been disputed by certain parties in interest, induces the present paper, which, it is hoped, will place the matter in such a clear light as to remove all doubt upon the accuracy of the results deduced.

As an index to the present investigation, it should be understood that for several years past a class of semi-mechanics have been peddling about the country various kinds of balanced slide valves, some of which are ingenious in construction, whilst the majority fail to command even casual attention, and all are worthless when placed squarely upon their merits, as their purpose is to substitute for an insignificant evil a greater though less obvious one. Owners of steam engines have been surfeited with circulars and testimonials commending the various traps; and after the benefits of the circular system have been completely exhausted, the inventor himself usually commences his pilgrimage. In due time he opens an assault upon some luckless owner of a steam engine, by explaining in technical terms the many virtues of his improved valve, and the utter lack of these desirable qualities in all valves hitherto in use. There are few owners of engines who can successfully resist the seductive charms of the "new valve," and in due time the owner consents to have his otherwise good engine "improved" by the industrious semi-mechanical missionary.

The projectors of these improved valves are rarely modest men. Those, however, having a regard for the remote future, limit their

claims of saving in cost of the power to be effected by the use of *their* valves at from 15 to 25 per centum, whilst others with a more elastic conscience usually estimate the benefits to be derived from "*their*" valves at from 25 to 50 per centum. Obviously, the only saving that a relieved valve can effect, as compared with an unrelieved valve, is the power expended in moving the latter. Conversely, there is not a single relieved valve in use, so far as the writer is aware, that has not, in a very short time after introduction, become so leaky as to render it a nuisance in the enormous quantity of steam passed into the exhaust, without performing its office in the cylinder, the steam thus wasted entirely obliterating any beneficial effect that might be obtained from a reduced load on the valve. Railway master mechanics who have investigated the relative merits of relieved and unrelieved valves, generally agree that the wear of links and joints of valve gears is least with relieved valves. Upon the other hand, they quite as unanimously agree that the relieved valves soon become excessively wasteful of steam, and that no increased economy of performance is perceptible in their use. Upon the whole, the experience of railway mechanics appears to decide the relieved valve as inferior to the plain slide valve (vide Rep. M. M. Convention, 1874).

The purpose of this article, however, is not in disparagement of relieved valves, but rather to show that such valves are the result of an imperfect knowledge of the friction of the unrelieved valve in its simplest form. That this imperfect conception of the true relative power expended in moving the valve is not confined to obscure persons, is evidenced by an article in the *Scientific American* under date of September 30th, 1876, in which the editor says: "If we consider the valve of an ordinary 16-inch cylinder engine to measure 8·5 by 14 inches, and allow a pressure of 130 pounds per inch in the steam chest, there would be, supposing the valve to bed perfectly on its seat, a pressure of $8{\cdot}5 \times 14 \times 130 = 15{,}470$ pounds forcing the valve to its seat; and the whole pressure upon the piston being 26,442 pounds, the friction of the valve would entail a loss of $\frac{15{,}470}{26{,}442} = 58$ per centum of the power of the engine."

The quotation contains two erroneous assumptions: first, that the friction is a measure of the area of the valve into the pressure per square inch independent of well-known coefficients of frictional con-

tact; and second, that the travel of valve is equal to the stroke of piston. Taking the data of the editor and allowing 20 per centum as the coefficient of friction for cast iron on cast iron, and the travel of valve as ·2 of the stroke of piston, then the power absorbed by friction of the valve becomes $58 \times \cdot 20 \times \cdot 2 = 2 \cdot 32$ per centum of the power of the engine, instead of 58, as estimated by the editor.

The general treatment of the "power absorbed by friction of the ordinary slide valve," in the accepted text-books on the steam engine, is vague and in nowise calculated to convey to the mind of the student the exact *status* of the problem. Rankine observes that "the slide valve is pressed to its seat, and the joint between it and its seat kept steam-tight by the excess of the pressure of the steam in the valve chest, behind the valve, which comes from the boiler, above the pressure of steam in the interior of the valve, which communicates with the condenser or atmosphere. The amount of pressure of the valve against its seat due to the pressure from behind is the product of the intensity of that pressure into the area of the face of the valve." Again, he says that "in the cases of large valves the load of resistance is unnecessarily great."

It is an undeniable fact that as the area of valve increases, the actual power required to move it increases; and in the case of large engines provided with slide valves, the force required to move them may be so great as to make it desirable that they be relieved, so as to allow ready manipulation in reversing and shifting the link, or other variable expansion gear: but if this convenience of handling, and reduced expenditure of power in moving the valve is obtained with a sacrifice of economy in the performance of the engine, the question presents itself whether it is not preferable to use the slide valve in its simpler form, with the corresponding economical performance, than to substitute relieved valves wherein the loss of steam between the valve face and its seat, into the exhaust, more than compensates for the increased facility of manipulation.

The writer is unaware of any experiments being reported, except by parties in interest, upon the relative economy of the different systems of slide valve: but from such data as he has been able to collect, he is of the opinion that the highest grade of economy is to be obtained from engines with the plain valve.

Evidently the expenditure of power in moving the ordinary slide valve is the moment of friction into the travel, and the moment of

friction is a function of the surface in contact and the unbalanced load on the steam side of valve (the total load being the area of the back of valve, parallel to the plane of motion, into the pressure in the chest). From this it appears incidentally that the smaller the valve for a given effect, the less the power absorbed in moving it. An erroneous idea prevails among engine builders that the friction of the valve is entirely independent of its size, and only dependent upon the area of steam passages which it covers. The fallacy of this conception will be evident in the following demonstration:

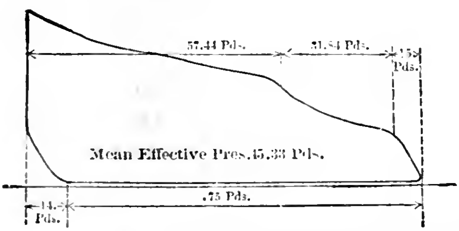
Let A represent the area of valve parallel to face impinged upon by the steam in the chest, and P the intensity of pressure in the chest. Assuming A as a constant for all positions of valve, then the total load upon the valve perpendicular to the plane of motion becomes $A \times P$; and were it not that a portion of this quantity is neutralized in its effect by a force also acting in a plane perpendicular to the motion of valve, and diametrically opposite to the force $A\ P$, then this latter, modified by a proper cöefficient, would represent the moment of friction at all points in the travel.

Let A' represent the effective area of under side of valve referred to, complete stroke of piston, and P' the corresponding mean pressure, then $A' \times P'$ is the neutralizing force: hence the moment of friction, F, is a function of $AP - A'P'$. Let B represent the travel of valve in feet: then the expenditure of power in overcoming the resistance of friction in the valve is expressed by the equation:

$$H = \frac{F \times B \times 2r}{33{,}000} \quad . \quad . \quad . \quad . \quad (1)$$

Let H' represent the indicated horse-power of engine, then the per centum of power, K, thus expended, becomes:

$$K = \frac{H}{H'}\,100 \quad . \quad . \quad . \quad . \quad . \quad (2)$$



To exemplify the foregoing principles the writer assumes an engine of 16-inch cylinder, 400 ft. speed of piston: slide valve $8\frac{1}{4}$ by 14 inches; travel, 5 inches; steam ports, 15 sq. inches area; exhaust port, 24 sq. inches area; pressure in the chest, 85 pounds; steam cut-off, at $\frac{2}{3}$ piston stroke. The diagram is from

an engine of these dimensions, and has been carefully estimated for this demonstration.

The area of valve parallel to the plane of motion is $8{\cdot}75 \times 14 = 122{\cdot}5$ square inches, pressure in the chest, 85 pounds, and the total load, $122{\cdot}5 \times 85 = 10412$ pounds; the counter-pressure acting upon the opposite side of the valve is made up of the mean pressure from admission to cut-off, acting upon an area equal to the area of steam port, for half travel of the valve in opening and closing port, hence:

$$\frac{15 \times 57{\cdot}44 \times 1{\cdot}25}{5} = 215{\cdot}4 \text{ pounds.}$$

The mean pressure from cut-off to release, acting upon an area equal to the area of steam port, for whole travel of valve during expansion:

$$\frac{15 \times 31{\cdot}84 \times 1{\cdot}25}{5} = 119{\cdot}4 \text{ pounds.}$$

The mean pressure from release to end of stroke, acting upon an area equal to the area of steam port, for half travel of valve during release:

$$\frac{15 \times 15 \times {\cdot}625}{5} = 28{\cdot}125 \text{ pounds.}$$

The mean counter-pressure from commencement of return stroke to exhaust closure acting upon an area equal to the area of exhaust pocket in valve, area of exhaust, pocket $12 \times 3{\cdot}75 = 45$ sq. in., hence:

$$45 \times {\cdot}75 \times {\cdot}9 = 30{\cdot}375 \text{ pounds.}$$

The mean cushion pressure from exhaust closure to opening of steam port at commencement of new stroke, acting upon, and equal to, the area of steam port for whole travel during compression:

$$\frac{15 \times 14 \times 1{\cdot}25}{5} = 52{\cdot}5 \text{ pounds.}$$

In addition to this is the value of the mean pressure from release to end of stroke, acting upon the area of exhaust pocket, and the counter-pressure during the latter part of return stroke, acting upon an area equal to the area of steam port for half travel of valve during exhaust closure, lacking the data necessary to estimate their values, these elements are omitted. Taking these several quantities together, the neutralizing force becomes:

$$445{\cdot}8 \text{ pounds, then } 10{,}412 - 445{\cdot}8 = 9966{\cdot}2 \text{ pounds.}$$

Assuming the coefficient of friction in this case to have been ${\cdot}15$, then $9966{\cdot}2 \times {\cdot}15 = 1494{\cdot}93$ the moment of friction, the double

travel of valve ·83 ft., and the revolutions per minute 100, then:

$$\frac{1494 \cdot 93 \times \cdot 83 \times 100}{33,000} = 3 \cdot 76 \text{ H. P.}$$

The mean effective pressure by the diagram is 45·33 pounds; area of piston, 201; piston speed, ·400; and the indicated power of engine becomes:

$$\frac{201 \times 45 \cdot 33 \times 400}{33,000} = 110 \cdot 5 \text{ H. P.}$$

and the per centum of power expended in moving the valve:

$$\frac{3 \cdot 76}{110 \cdot 5} \times 100 = 3 \cdot 4.$$

The opinion entertained by certain engineers that the slide valve floats on a thin film of steam between it and its seat, is not only untenable, but undesirable, for if the fit of the valve to its seat is such as to allow a circulation of steam of maximum pressure sufficient to balance the load (in part) upon the opposite side of the valve, it is likewise sufficient to permit the passage of steam between these surfaces into the exhaust. Again, considering the close relation that must necessarily subsist between the valve and the seat in order to *prevent* leakage into the exhaust, it is probable that the liquefaction of steam, due to the attraction of the metal surfaces, is sufficient to prevent the entrance of steam under the valve.

Safety of Railroad Traffic as ensured by the Block System of Signals.—A severe accident has occurred in England, on the line of the Great Northern Railway, near Arlesley, which shows that a perfect system of signalling is incapable of prevention of accidents, unless it is supplemented by infallible means of stopping a train within the signal limits. In this case with the signals at danger while a goods-train was crossing the line, upon which it broke down, the express-train of 15 carriages run through the signals at over 800 yards distance, and came in collision with the goods-train at a speed only checked from 60 to 20 miles per hour.

A continuous brake would have averted this catastrophe, but the perfection of such a brake is an indispensable condition for complete safety. It would seem that there is no possible perfect immunity from railway accidents.

GAS SUPPLY FROM WORKS WITHOUT A GASHOLDER.

By M. SERVIER.

Paper read at the last Annual Meeting of the *Société Technique de l'Industrie du Gaz en France.*

[From *The Journal of Gas Lighting*, London, Jan. 9th, 1877.]

The object of the communication I am about to make to the Society is to demonstrate the possibility of gas-works performing their functions without the aid of a gasholder. It is evident that here the question is not one of a normal supply, and though I made the experiment with it, I beg you to believe that it was not for my personal amusement. First of all, then, I will state the causes which led me to make this experiment, which was attended with perfectly successful results.

The contract for lighting the town of Metz has been but lately renewed, and the considerable reduction in price which has resulted therefrom—a reduction from 45 to 27 centimes per cubic mètre (about 10s. to 6s. per 1000 feet), upon which the town authorities impose a further tax of 5 centimes, making the net price 22 centimes—has proportionately developed the consumption of gas. It has also compelled us to seek for more economical modes of manufacture.

The old gas-works at Metz, constructed at a time when the railway was not in existence, were erected on the road from Metz to Saarbruck, where the coal mines are situated; but the railway terminus was built at the other end of the town, about three miles from the gas-works. The first piece of economy to be practiced in the development of the manufacture was, therefore, to move nearer to the railway terminus, and this we did by erecting a second gas station close to the line. This station was destined subsequently to replace the original works. These new works were furnished with larger retort-ovens, and so arranged as to manufacture gas more economically.

I was pledged to light the railway offices, etc., in the month of October, 1875, but, in consequence of delays, I was unable to complete the gasholder in time to be of service. Then came the frost, and, briefly, I found that the gasholder could not be brought into use till the Spring. However, I wished to fulfil my engagements, and add to the receipts the amount which the lighting of the railway offices would have brought us.

It was under these circumstances that I decided on starting the works without a gasholder, and I am about to point out to you the precautions to be taken in a similar case, and to explain how, although I got very well out of the difficulty, I might have done still better than I did, had I thought sooner of another solution, which I have just applied with a different object.

I ought at once to say that the existence of the old works, with the gasholder, facilitated the service I wished to effect, by reason of the connection existing between the two stations through the network of mains; but it will be seen that this condition is not necessary.

The day supply, as well as that which is furnished after midnight, is very regular in the majority of towns; that is to say, the hourly consumption is pretty nearly equal. This consumption being known, it is sufficient to charge the retorts with the quantity of coal absolutely necessary for the production of the amount of gas desired, sending the gas direct into the town. This is what was done during the day, and after midnight. With regard to the evening, the retorts were fully charged, and the two works being connected by the mains I was able by means of the governor, so to regulate the supply from the works provided with a gasholder as to leave the works unprovided with one to send out all the gas they produced. In this way the pressure on the retorts and other apparatus did not exceed the proper limits, which would not have been the case if the works without the holder had produced more gas than they were able to send out.

But this regulation of the charges during the day and night, and of the pressures during the evening, is not the only precaution to be taken in a service of this nature. You know, in fact, that the coal does not produce, during the different periods of its distillation, a uniform quantity of gas, or gas having a uniform illuminating power. The first portions of the gas produced, like those which are given off last, have a much more feeble illuminating power than the gas produced in the middle of the distillation. To remedy this serious inconvenience, the retort charges were fractionated as much as possible—that is to say, every hour a fourth of the retorts were charged in order to obtain a gas of an average illuminating power. We even noticed that, notwithstanding this precaution, it was necessary to add a small quantity of Boghead or cannel to each charge, to improve the gas produced at the commencement of the distillation.

It is equally necessary, during the lighting hours, to refrain from putting into use purifiers that have just been renewed, and contain air, which acts injuriously on the illuminating power of the gas, unless the precaution be taken to expel the air by means of valves in the covers.

The same supply could be afforded by a single work which, from any circumstance whatsoever, had been deprived of its gasholder; but it would be necessary to take a fresh precaution, which would be before sending the gas into the town, to cause it to pass through a small bell-shaped vessel suspended in water, and weighted to the maximum pressure, which it was desired that the apparatus on the works should bear. This vessel would be furnished with an outlet-pipe, which would allow the gas to escape whenever the proper pressure should be exceeded. The gas so escaping might go to waste, or, better still, be conveyed into the retort-oven, and there utilized for keeping up the heat. I should add, that in one case as in the other it is indispensable to entrust the service to intelligent and conscientious foremen.

I have already said that I could have done still better if I had thought in time. This is what I am now actually doing, although the gasholder is in use, but with a different object, which I am about to indicate to you. I have remarked that the new works were capable of manufacturing gas at a lower rate than the old, consequent upon the economy effected in the transport of the coal and the employment of improved apparatus. But beyond this the old works possess extensive gasholders and large outlet-pipes. These I was desirous of utilizing, while making the gas exclusively in the new works, at least during a great portion of the year. For this purpose I connected one of the outlet-pipes at the old works, in front of the outlet-valve, with the inlet to the exhauster. In this way the old works draw off by means of the network of mains, the gas made during the day by the new, store it in the holders, and send it out in the evening through the large outlet-pipes. I can thus draw off 150 cubic mètres (about 5000 cubic feet) per hour without any inconvenience. I do not increase the leakage, as the suction of the exhauster is so regulated that the pressure on the mains is unaltered. There is, however, a slight oscillation produced by the exhauster, which is on Beale's system; but that is of no importance for day consumption, and moreover could be entirely suppressed by using one of Schiéle's or Körting's exhausters, the action of which is much more

regular, or by interposing a governor between the main and the exhauster. But I repeat, the oscillation is so slight that it is not even necessary to make this addition.

You see, then, that I could have saved myself the trouble of regulating the retort-charges with so much care on the works unprovided with a gasholder, by drawing off, as I now do, the gas produced there, and storing it in the holders on the second works. But we do not always think of everything, and thus an opportunity was afforded me of making an experiment which perhaps may be of some use in exceptional cases.

Roll Turning.[1]—The three memoirs on roll turning, to which prizes were awarded a few years since by the Verein zur Beförderung des Gewerbfleisses in Preussen (Prussian Society for the Promotion of Industry), have just been issued by permission of the Society as a separate volume of 135 large quarto pages, with 33 lithographed plates, and 108 cuts in the text. The volume is obtainable in this country of Messrs. Williams & Norgate, of Henrietta Street, Covent Garden, and as the price—24*s.*—is not high, it will, doubtless, be accorded a place in the library of all iron manufacturers who desire to keep themselves informed with regard to what is being done by their rivals in Germany. It will be recollected that some ten years since the Society offered prizes of 500 thalers and 250 thalers respectively for the best and second best memoirs upon the subject in question, the offer of the prizes being the result of a discussion which took place at one of the meetings of the preceding year. The various points upon which information was sought were carefully detailed in the conditions of competition, and the several competitors were required to send in their memoirs, distinguished by motto only, in the usual way, so that the selection for the award was necessarily made upon merit alone. The award having been made it was found that the 500 thaler prizes had been gained by Mr. R. Daelen, superintendent engineer at Hörde, now owner of a factory at Heerd, near Düsseldorf, and by Mr. A. Hollenberg, engineer, at Sterkrade, now superintendent engineer at Essen; whilst the 250 thaler prize was gained by Mr. Diekmann, engineer, at Eschweiler-Pümpchen, near Aix-la-Chapelle. The memoir by Mr. Daelen is concise, and to the point, the various arrangement of rolls, two and three high,

[1] From the *Mining Journal*, London, Jan. 6th, 1877.

being described, and the method of ensuring their accurate working explained; ample details are also given as to roughing and finishing rolls for ordinary merchant bars, and to the rolls for the production of special sections. The details given by Mr. Hollenberg are still more minute, and will be found to be of equal practical value, whilst Mr. Dickmann's memoir is also an admirable one. Whether the manufacture be principally engaged in rolling T, double T, U, angle iron, hoops, rails, bars, tramplates, or special sections, he will find so much information of the precise character he requires that even should he disagree with some of the conclusions arrived at, he will at least be prevented from falling into error by neglecting the consideration of details which demand attention.

ORIGIN OF PETROLEUM.

Mr. H. Byasson has been led by the following experiment to give a scientific explanation of the formation of petroleum: If a mixture of vapor of water, carbonic acid, and sulphuretted hydrogen be made to act upon iron, heated to a white heat in an iron tube, a certain quantity of liquid carburets will be formed. This mixture of carburets is comparable to petroleum.

The formation of petroleum can thus be naturally explained by the action of chemical forces.

The water of the sea, penetrating into the cavities of the terrestrial crust, carries with it numerous materials, and especially marine limestones. If the subterranean cavity permits these new products to penetrate to a depth where the temperature is sufficiently high, in contact with metallic substances, such as iron or its sulphurets, we have a formation of carburets. These bodies will form part of the gases whose expansive force causes earthquakes, volcanic eruptions, etc.

Petroleum is always found in the neighborhood of volcanic regions or along mountain chains.

In general it will be modified in its properties by causes acting after its formation, such as partial distillation, etc. Petroleum deposits will always be accompanied by salt water or rock salt. Often, and especially where the deposit is among hard and compact rocks, it will be accompanied by gas, such as hydrogen, sulphuretted hydrogen, carbonic acid, etc.—Translated from the *Revue Industrielle* for the *American Manufacturer.*

VENTILATING APPARATUS.

[From the Secretary's Report to the Meeting of the Franklin Institute, Jan. 17, 1877.]

There were exhibited at this meeting several modifications in the caps of chimney or ventilating shafts, and in deflectors for currents from hot-air registers, which had been designed and put into practical use by Mr. Wm. Welsh. These appliances were described in full, as follows:

First, a chimney or ventilating shaft was protected from the weather and any wind, which might at any time exist about the top and was made to induce an outflowing, upward current, by a cap of peculiar construction, as shown on Fig. 1. This cap could be round, but might preferably be square; it had a surface, inclined at about 45°, which came to a sharp point at the flue, so that any horizontal current of air which exists at the time should be deflected upwards, and thus induce the ascending smoke or foul air in the flue to pass out with it. The top was protected by a flat plate, which was made to extend well over and beyond the inclined surface, so that any downward current in the external air would be transformed into a horizontal one in some direction, before reaching this inclined surface. In so far as this description goes, the cap is that well known as Emerson's Ventilator, which was patented about 1847,[1] but Mr. Welsh has found great advantage in the addition of four vertical radial wings or plates, which answer the purpose of preventing whirls of descending external currents from choking the efflux from the flue. In fact these whirls, which frequently exist wherever the chimney-top is surmounted in elevation by houses or roofs, now are made somewhat effective in inducing a draft in the chimney or ventilating flue, while they also, by *catching* in the funnel-shaped mouth the full force of the horizontal, or nearly horizontal, currents, ensure the best effect from these currents on the affluent smoke or air.

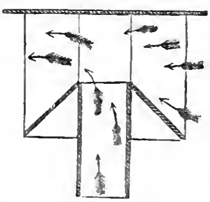


Fig. 1.

[1] This form of ventilator was really originated by Cisalpen, ninety-nine years ago. See Memoir in Phisiq. de M. Rozier, Tome ix, 1777.

Second, a ventilating shaft, in which the inducement for ascent of the foul air current is given from heat proceeding from an internal smoke flue (an arrangement at once common, and generally satisfactory), will be found more efficient if the cap be constructed as shown on Fig. 2. The smoke flue (of cast iron preferably) is made to stop short, below the outlet of the stack, so that a commingled volume of air and smoke escapes at the top. This arrangement was effectual in taking advantage of the hot gases current, as a *jet*, to quicken the discharge of the air flue; at the same time, the increase of temperature of the currents was made more certain than by mere contact with the smoke-stack, and the construction of the stack was greatly simplified. This disposition was practically in use in the new pavilion wards at Wills' Hospital, and at the Pennsylvania Institution for the Deaf and Dumb, where the system of ventilation was rendered very effectual by its means.

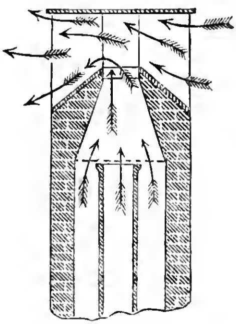


Fig. 2.

Third. For larger shafts and ventilating louvers, Mr. Welsh proposed the arrangement shown on Fig. 3. The lower part of this louvered opening, Mr. Welsh proposed to construct similarly to the caps Fig. 1 & 2, with radial wings in the four corners of the louver in the same way, but above this to employ a system of blinds or slats of peculiar form, so that a current of wind blown against them would be *deflected*, inducing an outward flow from the narrow slits left between the upper edge of one deflector strip and the under side of the next above it. This supposed effect will be readily comprehended by reference to the figure and its arrow.

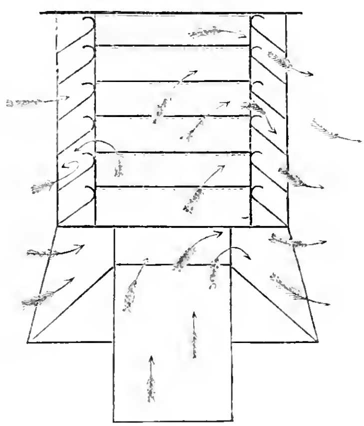


Fig. 3.

Fourth. For the louver openings of shafts for *supply* of air to a system of ventilation, Mr. Welsh proposes an arrangement of blinds or slats, and internal construction as shown on Fig. 4; by so forming

the slats as to present a wide open mouth to the current of wind, constraining it to deviate from a horizontal direction and thus directing its discharge downwards into the shaft. By this means the force of the wind itself will be rendered available on one side certainly, and possibly on two sides (if the direction of the wind is diagonal to the position of the square louver). Within the louver and for a short way down the shaft, some division plates separate it into four flues. These division plates preclude any direct flow of the air across the louver—to escape at the opposite side and ensure a determinate downward current in the flues on the windward side of the louver or shaft—while this downward current *induces* in part a similar flow in the flues on the leeward side, the blinds of which receive their air from the whirl which the wind will make over the louver as it does over any obstacle whatever.

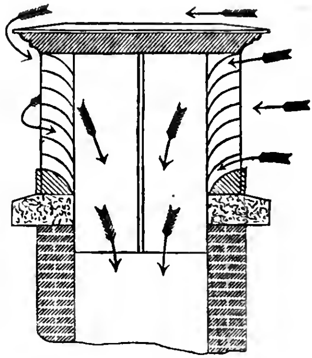


Fig. 4.

In the ventilation of buildings by self-acting currents it is well known that in high winds the heating air refuses to enter at the registers of the lower exposed rooms. The pressure of wind against the windows, the leakage, and possibly the passage of some air through the wall itself, will have produced such a plenum in these rooms as to oppose the entry of air at the usual flues. Sometimes the air of a room thus situated will actually flow back to the heater through the flues, and the system of ventilation will be reversed, the room being supplied with *cold* air by leakage or otherwise. This construction of ventilating shaft now provides a pressure upon the cold air supply for the furnaces quite equal in value, and possibly exceeding that which the wind will have established in the exposed room, and the entry of a current of hot air is thus ensured for that room, regardless of the force of the external wind.

Fifth. For the distribution of heated air in a room, Mr. Welsh proposed to have constructed a *deflector*, as shown on Fig. 5. This *deflector* would, by a judicious shape of blades, direct the current of heated air upon the floor of the room, in place of allowing it to escape horizontally at first emergence and thence ascend, like a reversed discharge of water, in a curved line to the ceiling. When the current of heated air once was established on the surface of the floor, it would not, according to

Fig. 5.

well known observations (first made by Venturi, who found that a jet of air would never leave a surface upon which it is blown), arise from the floor until it is diverted from it, by some object of resistance. This apparatus has proved very successful in practice, and Mr. Welsh has made some arrangements for its introduction into general use in promoting a healthy equality of temperature of air in occupied rooms. Another arrangement of deflector is shown on Fig. 6, suited for giving a horizontal surface direction to currents from floor registers. The figure and arrows show the effect of the deflecting plate, which is so shaped as to offer the least resistance to the stream of air compatible with the change of direction.

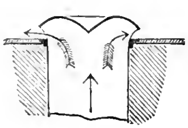


Fig. 6.

Sixth. For the control and distribution of inflowing currents, either under great variations of pressure, or when a small flue is employed in which the air attains a high velocity, while it is desirable that the entering current shall be nearly imperceptible, the arrangement on Fig. 7 is proposed. By this disposition of ⊢⊣ bars, the direction of the current is so baffled, and so many eddies produced, that the vehemence of any stream of air is quite spent when the front of the *distributor* is reached by it.

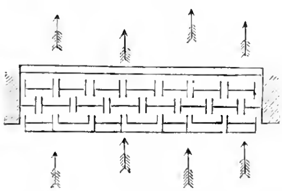


Fig. 7.

Except the fifth of the list, the right for which Mr. Welsh has donated to some charitable purposes, none of these several arrangements have been or will be patented. Whatever novelty or value the others may possess, Mr. Welsh has taken this means of making them public, for the purpose of rendering them free from patent fees, for all persons who may at any future time have occasion to use them.

Heating Railway Carriages.—All classes of carriages on the Alsace-Lorraine lines are now warmed, the supply of heat being the boiler of the locomotive. Metallic standpipes are placed in each carriage beneath the seats, connecting with a main running the length of the carriage. Each of these is connected with the next by india-rubber tubing, the whole forming a continuous supply. Each compartment has its own supply, which the passengers can regulate for themselves, by moving a lever placed on a sector bearing the words *cold, warm, hot.*—*Iron.*

ON THE LANCASHIRE BOILER,

ITS CONSTRUCTION, EQUIPMENT, AND SETTING.

By Mr. Lavington E. Fletcher, of Manchester.

[From the *Proceedings of the Inst. Mech. Engineers*, London, May, 1876.]

The Lancashire type of Boiler differs only from the Cornish in one point, namely, that the Lancashire boiler has two furnace-tubes whereas the Cornish has but one. In both types of boiler the shell is cylindrical, the ends are flat, and the furnace tubes are carried through from front to back below the ordinary water line, while the boilers are laid horizontally and fired internally. Internal firing is essential either to a Lancashire or to a Cornish boiler. It is a mistake to speak of an "externally-fired Lancashire" or an "externally-fired Cornish" boiler, though this is frequently done. If the fires are taken out of the furnace-tubes of a Lancashire boiler and put underneath, it is a Lancashire boiler no longer, but becomes an externally-fired double-flued boiler; and if a Cornish boiler be treated in the same way, it becomes an externally-fired single-flued boiler. These boilers owe their names to the counties in which they were first brought into general use. The single-furnace boiler was introduced early in the present century by Trevithick in Cornwall, and is therefore called Cornish. The double-furnace boiler was introduced in 1844 by Fairbairn and Hetherington in Manchester, and is therefore called Lancashire.

In laying down Lancashire boilers, the fact has been too frequently lost sight of that directly a fire is lighted within them they begin to move, the flat ends to breathe outwards, the furnace tubes as well as the shell to hog upwards, and the whole structure to elongate. If sufficient allowance is not made for these movements, straining and sometimes rupture occurs, while the tendency to this is frequently aggravated by putting in an extra thickness of metal with a view of adding strength, the additional thickness increasing the unequal expansion of the parts. For some years the writer has had opportunities of observing a large number of boilers of the Lancashire as well

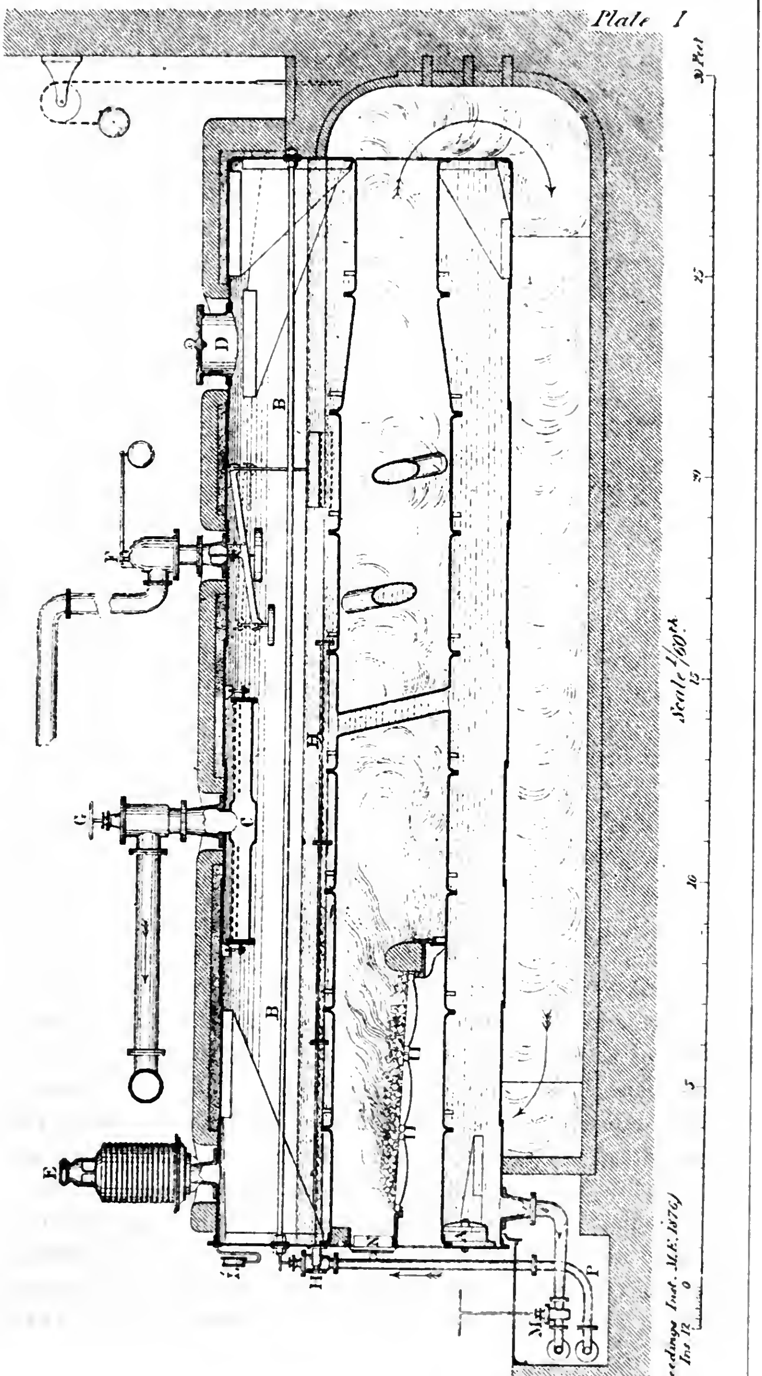
as other types, in work under the inspection of the Manchester Steam Users' Association; and as the result of these observations he has been led to recommend for the use of its members such a construction of boiler, such an equipment, and such a mode of setting, as that described in this paper. This boiler has been very generally adopted by the members, and found to give satisfactory results. It was thought therefore that a description might be of service to the Institution of Mechanical Engineers. It is not set forth as a work of origination but one of selection and adaptation. The boiler described is safe for a working pressure of from 75 to 100 lb. per sq. in. Its structure is elastic, so that it may not be rent or disturbed by the movements of the parts, resulting from alternate expansion and contraction; and it is so set and the fittings are so arranged that the whole may be above board and accessible to inspection The writer does not agree with the view, so obstructive to improvement, but too generally held, that anything will do for a boiler, and that it is only a boiler after all. He thinks that a boiler should receive as much attention as an engine; that it should be made with as much accuracy and attended with as much care; that the fireman should not be condemned to work in a dark dirty cellar, called a stoke-hole, and the boiler be assumed to be necessarily black and grimy; but that the boiler should be placed in a suitable house kept bright and cheery, and the fittings as well as the whole structure kept clean and in first-rate working order; also that the fireman should be stimulated to become as proficient in the art of using his shovel and managing the fire as a fitter in using his file and erecting an engine. If this practice, happily adopted by some, were to become general, and first-class boilers were laid down instead of low-priced ones, the scientific boiler-maker would have fairer scope, the steam user would derive economy, and the public would be benefited by the prevention of explosions as well as by the abatement of the smoke nuisance.

The Lancashire boiler has many variations, besides the simple form already described. There is the Galloway boiler, in which the furnaces instead of running through from one end to the other unite in an oval flue strengthened with conical water pipes. There is the Multitubular, in which the furnace-tubes unite in a combustion chamber, from which a number of small flue tubes about 3 in. diameter and 6 ft. long run to the back of the boiler. There is Hill's Multiflued boiler, in which seven flues about 11 in. diameter and 8 to 10 ft. long

Plate I

LANCASHIRE BOILER.

Fig. 1. Longitudinal Section.



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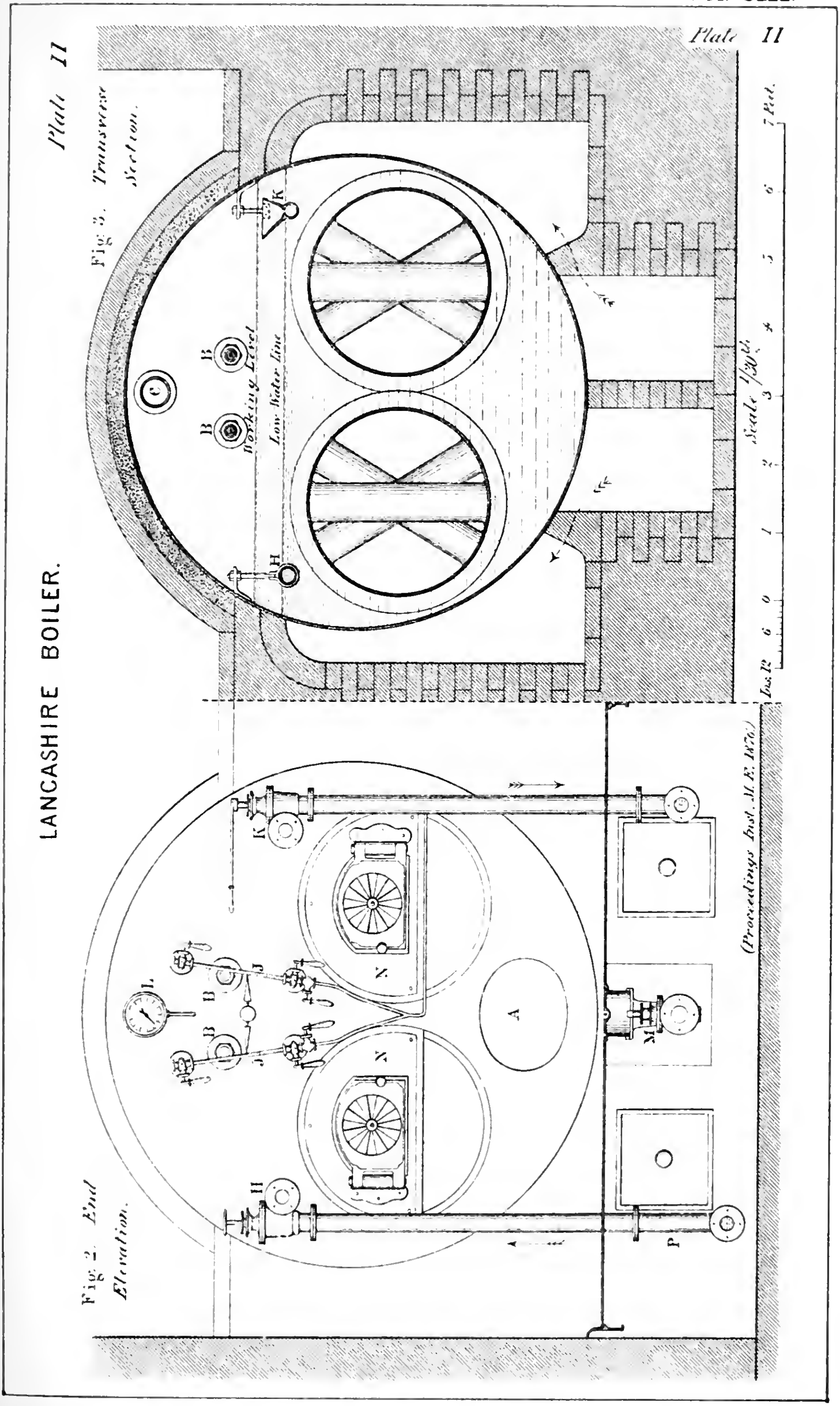


Plate II
LANCASHIRE BOILER.
Fig. 3. Transverse Section.
Working Level
Low Water Line
Scale 1/30th
Fig. 2. End Elevation.
(Proceedings Inst. M.E. 1876.)

take the place of the small flue tubes in the multitubular boiler. There are also others in which the furnace-tubes branch off to the sides or the bottom of the shell, instead of running right through to the back end. To all these variations of the Lancashire Boiler, and also to the Cornish, this paper applies as regards the construction of the shell and furnace-tubes, as well as in regard to the setting and equipment of the whole.

To assist in the construction of Lancashire boilers for high pressures, the Manchester Steam Users' Association authorized the making of a boiler expressly for undergoing a series of hydraulic bursting tests; and the manufacture of the boiler was entrusted to Mr. Beeley of Hyde Junction, who rendered valuable assistance in the prosecution of the trials. This experimental boiler was 7 ft. diameter, which is the usual size for mill service, and was adapted for a working pressure of 75 lb. per sq. in. Eleven experimental bursting tests have been made, careful observations being taken of the behavior of the boiler while under pressure. These tests have furnished valuable information, and when they are completed the results will be fully published. Some of the results are given in this paper. In order to preserve the precise form and character of the rents produced, the solid plating around them has been cut out of the boiler intact; several of these specimens are exhibited at the meeting. An actual end plate of a boiler 7 ft. diameter, got up and equipped in accordance with the standard adopted by the Manchester Steam Users' Association, has been prepared for exhibition.

In describing the boiler under consideration, which is shown in Figs. 1 to 3, Plates I and II, it is proposed to treat first on its construction, secondly on its equipment, thirdly on its setting, and then finally to give a few particulars as to weight and cost, heating surface, and working results.

Construction.

Dimensions.—Short boilers are found to do more work in proportion than long ones; this has been confirmed by experiments on the rapidity of evaporation by Mr. Charles Wye Williams and others. Also short boilers strain less than long ones, and are therefore less liable to need repair. A length of 30 ft. should be the maximum, while with regard to the minimum some Lancashire boilers to suit particular positions have been made as short as 21 ft. and found to work well,

though the fittings become rather crowded. The length recommended and now generally adopted is 27 ft.

The diameter of the boiler is governed by the size of the furnaces, which should not be less than 2 ft. 9 in. to admit of a suitable thickness of fire and afford convenience in stoking. Thick fires are more economical than thin ones. The space between the two furnace-tubes should not be less than 5 in., and that between the furnace-tubes and the side of the shell 4 in., in order to afford convenient space for cleaning and for the free circulation of the water, as well as to give sufficient width of end plate for enabling it to yield to the expansion and contraction of the furnace-tubes. With this width of water space it will be found that furnace-tubes having a diameter of 2 ft. 9 in. require a shell of 7 ft., which will afford a headway of about 2 ft. 9 in. from the crown of the furnaces to the crown of the shell. A furnace 3 ft. diameter gives room for a thicker fire than one 2 ft. 9 in., but it requires a shell 7 ft. 6 in. diameter. For high pressures, the smaller diameter of 7 ft. is generally preferred, and has come to be adopted as a standard size for mill boilers throughout Lancashire, though one of 7 ft. 6 in. makes a good boiler and gives a greater Ind. H. P. per lineal foot of frontage than one of 7 ft. The diameters both of the shell and of the furnace-tubes are measured internally, that of the shell being taken at the inner ring of plating.

Ends.—The ends, more especially the front, are the seat of the grooving action which occurs in Lancashire boilers when disproportioned. These grooves occur inside the boiler and around the furnace mouth, as shown at *R S* in Figs. 4 and 5, Plate III. They are the product of mechanical and chemical action combined. The plate is fretted by being worked backwards and forwards by the movement of the furnace-tubes consequent on the action of the fire, and when in that condition is attacked by the acidity of the water. To prevent this grooving, the ends should be rendered elastic so as to endure the buckling action without fatigue. To secure this elasticity there should be not only a sufficient width of end plate between the two furnace-tubes as well as between them and the shell, as already explained, but also a space of 9 in. between the centre of the bottom rivet in the gussets and those at the furnace mouth. Also five gusset stays are found to work in better than any other number. With five gussets, one falls on the centre line, which is not only the weakest part of the front end plate and thus where it requires the

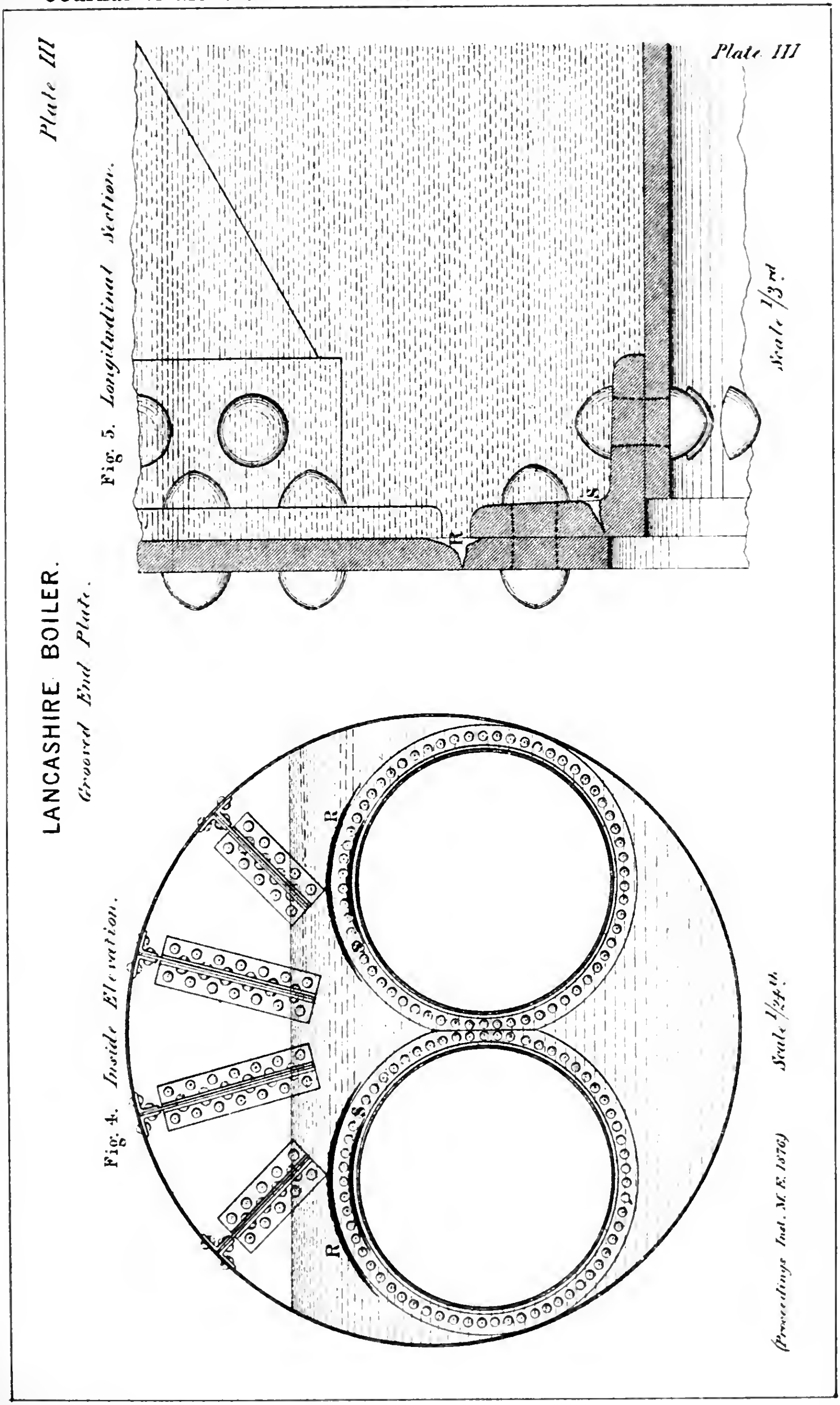


Plate III
LANCASHIRE BOILER.
Grooved End Plate.
Fig. 4. Inside Elevation.
Scale 1/24th.
Fig. 5. Longitudinal Section.
Scale 1/3rd.
Plate III
R
S
(Proceedings Inst. M. E. 1876)

most support, but also where it can be held fast without resisting the movements of the furnace-tubes. The part of the end plate that should be left free is that immediately over the furnace crowns. With four gussets, as shown in Fig. 4, the end plate is more unguarded at the centre, which is the weakest part, and more confined immediately over the furnace-tubes, which is the line of motion.

The thickness of the end plates is sometimes as much as $\frac{3}{4}$ in. for pressures of 60 lb. per sq. in. This thickness however is quite unnecessary, and only tends by its rigidity to cramp the furnace-tubes and strain the parts. Half an inch has been repeatedly and successfully adopted in boilers for pressures of 75 lb. per sq. in., and $\frac{9}{16}$ in. when that pressure has been exceeded. These thicknesses have proved amply sufficient.

In applying the hydraulic test to boilers of the construction and proportions now described, before leaving the maker's yard, it is the practice to carry the pressure up to about 150 lb. per sq. in., and to strain fine cords across the flat ends to act as straight edges from which to gauge the ends, measurements being taken at twelve points before the test, during the test, and after the test. It is found as a rule that the plate under pressure bulges outwards at the centre from $\frac{1}{16}$ to $\frac{1}{8}$ in., and on the removal of the pressure returns to its original position without suffering any permanent set. In the experimental hydraulic bursting test, the ends, though only $\frac{1}{2}$ in. thick, have stood repeatedly a pressure of 275 lb. per sq. in. without leakage or any appearance of distress; but on the pressure being raised to 300 lb. the front end plate displayed signs of weakness in the vicinity of the mudhole *A* beneath the furnace-tubes, Fig. 2. With this exception the greatest bulging was $\frac{1}{8}$ in. at the front, and $\frac{3}{16}$ in. at the back, while the greatest permanent set was only $\frac{1}{16}$ in.

Longitudinal stays are frequently introduced to assist the end plates. In the experimental tests the longitudinal stays were taken out, so that it is clear they are not absolutely necessary where the gussets are substantial. Should it however be thought desirable to adopt them, either as an extra precaution or as afterclaps to assist the gussets when too weak, they will be found easy of introduction. They are therefore shown at *B* in Figs. 1 and 3, and it will be observed that they are secured at each end with double nuts, one inside the boiler and one outside, and are placed as much as 11 in. above the level of the furnace crowns, and as close together as con-

venience will allow. When placed directly over the furnace crowns, and only a few inches above them, they confine the furnace-tubes too strictly, and straining ensues. A single stay on the vertical centre line of the front end plate is correct in principle, but two are more convenient in application.

To increase the elasticity of the front end plate, it is attached to the shell by an external angle-iron rather than by an internal one or by flanging. It is not necessary to attach the end plate at the back of the boiler with an external angle-iron, and when this has been done the angle-iron has been found to be injured by the action of the flame.

Both of the end plates, instead of being made in two pieces riveted together at the joint, are welded. This affords a flat surface, which in the case of the front end is more convenient for the attachment of the mountings. Also both of them are turned in the lathe at the outer edge, so as to be rendered perfectly circular, and are bored out at the openings for the furnace-tubes.

Furnace-Tubes.—The longitudinal joints in the furnace-tubes are welded when the plates are of iron, and double-riveted when of steel, each belt of plating being made in one length and thus having but one longitudinal joint. All the transverse seams of rivets are strengthened with Adamson's flanged joint, or with an encircling hoop either of Bowling iron, T iron, or other approved section. Adamson's flanged seam is shown in cross section in Fig. 6, Plate V, the T seam in Fig. 7, the Bowling hoop in Fig. 8, and the Bolton steel hoop in Fig. 9. One of the evils that has attended internally-fired boilers has been the frequent collapse of the furnace-tubes; but this danger is completely avoided by strengthening the tubes as just described, whereby, instead of being weaker than the shell as before, they are rendered stronger. This has been shown by the experimental bursting tests, in which, while the shell has been burst repeatedly, the furnace-tubes have not suffered at all, nor shown any movement on being gauged. In some cases Petrie's water pockets, shown in Figs. 12 and 13, Plate 9, and in others Galloway's conical water pipes, shown in Fig. 11, are introduced as a precaution against collapse; while in others again the water pipes are made parallel, as in Fig. 3, and either riveted or welded in place, so as to form one piece with the flue tube. In all cases however the transverse seams of rivets over

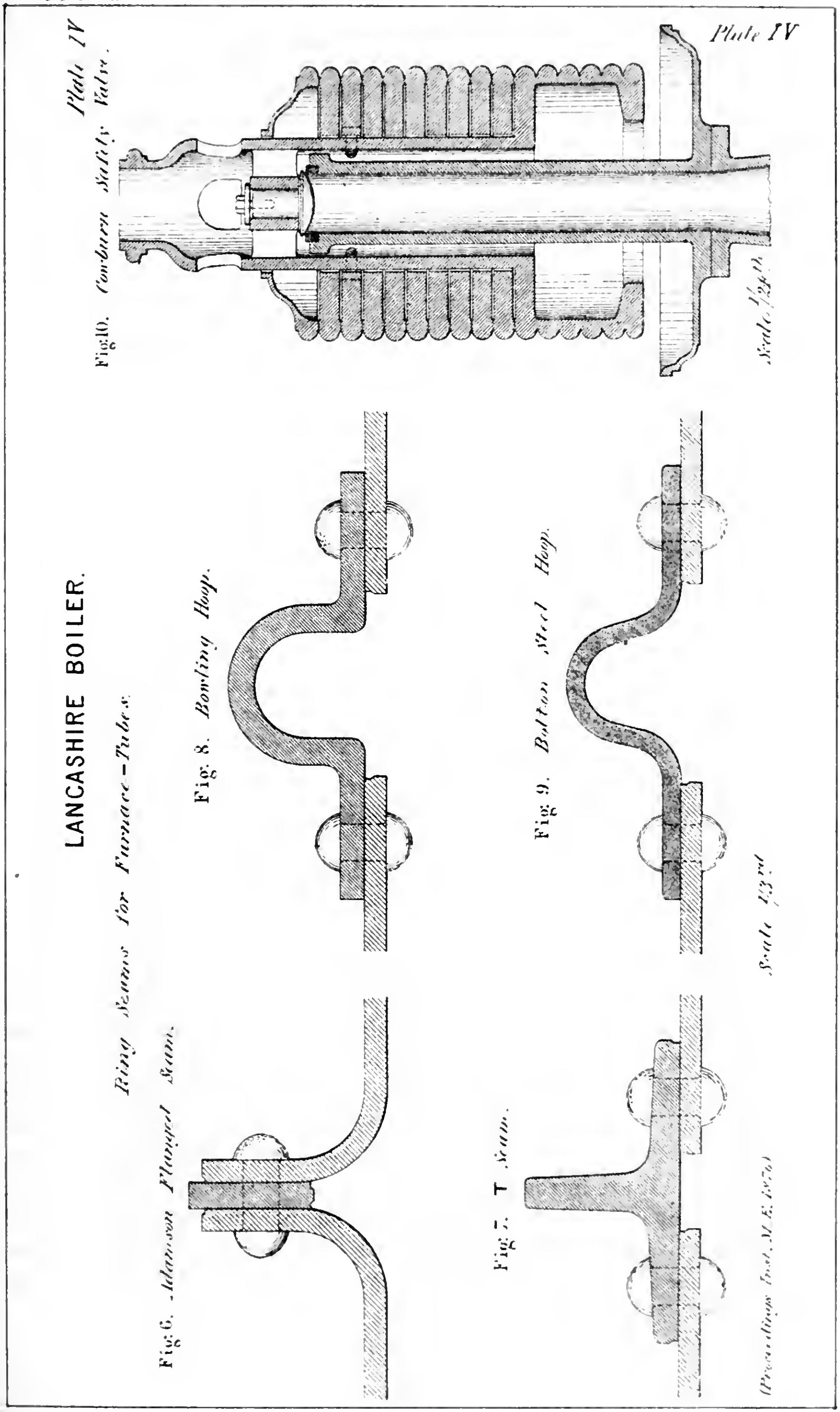


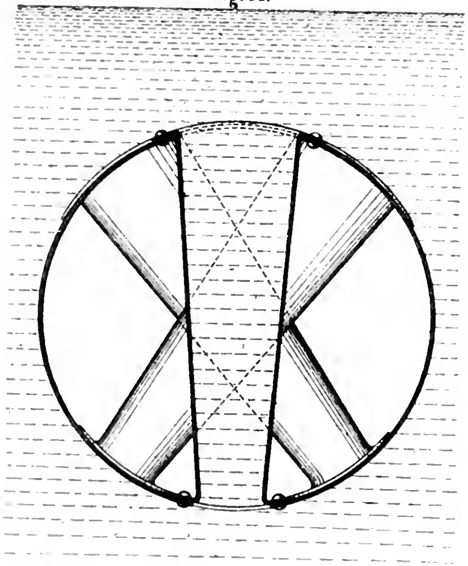
Plate IV
Fig. 10. Cowburn Safety Valve.
Scale 1/24th
LANCASHIRE BOILER.
Ring Seams for Furnace-Tubes.
Fig. 8. Bowling Hoop.
Fig. 9. Bolton Steel Hoop.
Scale 1/3rd
Fig. 6. Adamson Flanged Seam.
Fig. 7. T Seam.

LANCASHIRE BOILER.

Plate V

Galloway Water Pipes.

Fig. 11.



Petrie Water Pockets.

Fig. 12.

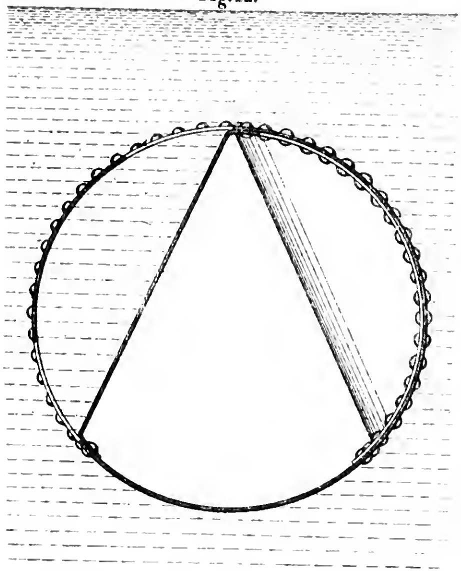
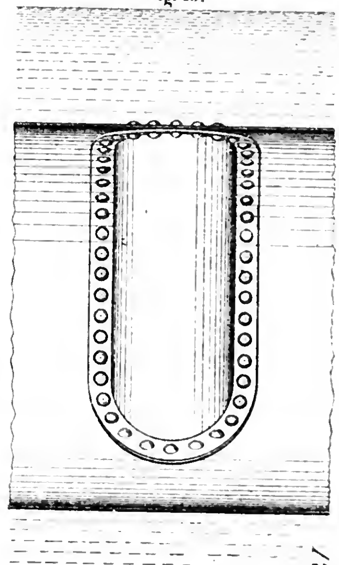


Fig. 13.



(Proceedings Inst. M.E. 1876)

Scale 1/16th.

Ins. 12 6 0 1 2 3 Feet.

Plate V

the fire should be strengthened with flanged seams or encircling hoops: and it is considered desirable to continue this mode of construction throughout the entire length of the boiler, whether water pockets or water pipes are introduced or not.

The thickness of the plates in the furnace-tubes is sometimes as much as $\frac{1}{2}$ in. This leads to violent straining and frequent leakage at the furnace mouths and other transverse seams of rivets. Many furnace-tubes 2 ft. 9 in. diameter, though only $\frac{5}{16}$ in. thick, have stood a hydraulic test of 120 lb. per sq. in. without movement, and have worked satisfactorily for years at a steam pressure of 60 lb. It is advisable however to have them a little thicker than this, in order to afford a margin for waste through corrosion, and also, when the flanged seam is adopted, in order to allow for the thinning that occurs in drawing the metal to make the flange. A thickness of $\frac{3}{8}$ in. is sufficient for a working pressure of 75 lb. per sq. in., $\frac{13}{32}$ in. for a pressure of 80 lb. or 90 lb., and $\frac{7}{16}$ in. for 100 lb. per sq. in.

Stays are sometimes introduced for supporting the furnace-tubes. Such stays however in the Lancashire boiler are unnecessary, and when rigid are decidedly objectionable. Furnace-tubes should be left free to move. As soon as a fire is lighted within them the top of the tube becomes hotter than the bottom and elongates. This makes the tube arch upwards. In conducting a series of trials in 1867 and 1868 for the South Lancashire and Cheshire Coal Association on the evaporative efficiency of their coals, and also on the comparative merits of different boilers, the writer had three gauge-rods attached to the crown of the furnace-tubes of two Lancashire boilers, and carried up vertically through the external shell by means of brass stuffing-boxes, so that a ready opportunity was afforded of witnessing the rise and fall of the furnace-tubes; while as the gauge-rods divided the tubes into equal lengths, a comparison could be drawn as to the movements of the different parts. Constant observation showed that the distortion of the tubes varied very much at different times, being most severe shortly after lighting the fires, while the colder the water to start with, the greater was the rise of the crown. As soon as the water became generally heated the gauge-rods retired to their old position, and the distortion of the furnace-tubes seldom lasted more than an hour. The boilers were 28 ft. long, the furnace-tubes of steel $\frac{5}{16}$ in. thick in one case, and of iron $\frac{3}{8}$ in. in the other. Care

was taken not to strain the boiler by severe firing, steam being got up with the dampers only partially open. Yet the furnace-tubes rose $\frac{3}{8}$ in. when the flames passed around the boiler in the external brickwork flues in the ordinary way, and $\frac{1}{2}$ in. when they passed off direct to the chimney without heating the outer shell. The curve that the flue appears to assume is not a segment of a circle. The gauge-rod at a quarter of the length of the boiler from the front showed in one case as high a rise as the rod placed midway in the length of the boiler, and in another case $\frac{1}{16}$ in. more. This is just what might be expected from the local action of the fire, and accounts for the grooving action being far more severe at the front end of a boiler than at the back, and shows the importance of affording greater elasticity at that part. Furnace-tubes lashed to the shell often tear themselves away from it in ordinary work, and the fractured stay rubbing against the shell leaves a witness of its movements, the amount of which frequently exceeds that just mentioned. In one case a furnace-tube that had a stay tying it to the top of the shell was found to have crumpled up the stay and broken it by an upward thrust, showing how little need there had been for trying to keep the furnace-tube from drooping.

Shell.—The shell, which is $\frac{7}{16}$ in. thick for a pressure of 75 lb. per sq. in., and $\frac{9}{16}$ in. thick for a pressure of 100 lb., is composed of plates about 3 ft. wide, which are laid in not more than three lengths round the circumference, in order that the longitudinal seams may clear the brickwork seatings. The longitudinal seams are so arranged as to break joint and avoid the centre line along the top and bottom of the boiler. In all the longitudinal rents obtained under the experimental hydraulic tests, the plates bulged outwards at the middle of their width, and this action was observed to a slight extent before rupture, showing that the greatest strain and thus the point of first fracture occurred at or near the centre line of each plate. This would seem to show that breaking joint is of practical advantage, and that a boiler composed of wide plates is not so strong as one composed of narrow ones.

There is no steam dome. Steam domes are expensive, they weaken the shell, and often give trouble from leakage at the base. Added to this they are inconvenient in carriage, as well as in revolving a boiler on its seat, as it is sometimes desirable to do for repairs; they

are also inconvenient in covering the boiler over, and in the great majority of cases, if not in every instance, they are for stationary boilers perfectly useless. To prevent priming, an internal perforated pipe *C*, Figs. 1 and 3, is adopted in place of the dome. Under hydraulic pressure with a steam dome 3 ft. diameter, $\frac{7}{16}$ in. thick, and the whole of the shell plate at its base cut away so as to form an opening as large as itself, the flange at the base of the dome ripped at a pressure of 150 lb. per sq. in. At a second trial with a dome of the same diameter, and a portion only of the shell plate cut away, the dome strained so much round its base and caused such violent leakage that a pressure of more than 235 lb. could not be obtained. At a third trial, the steam dome having been removed and refixed with stouter rivet heads, so as to resist the upward strain that was induced, the flange at the bottom of the dome ripped on the centre line of the boiler at a pressure of 260 lb. per sq. in. In this instance the workmanship was all good and sound, but where the quality of the plates is inferior or the domes are attached with reedy angle-irons, the weakening effect must be much greater. Steam domes clearly establish a weak point in a shell, and are better avoided.[1]

The manhole *D*, Fig. 1, is guarded with a substantial raised mouthpiece of wrought iron, welded into one piece, flanged at the bottom and attached to the boiler with a double row of rivets, the thickness of the upper flange being $\frac{7}{8}$ in., and of the body $\frac{3}{4}$ in. This has been found to stand a test of 300 lb. per sq. in. without the slightest indication of straining. A raised wrought-iron manhole mouthpiece is exhibited. It is too frequently the practice not to strengthen manholes with any mouthpiece at all. Many explosions have arisen from this cause, rents starting in the first place from the unguarded manhole, and then extending all over the boiler. The loss of strength

[1] A striking illustration of the weakness of steam domes has recently been furnished by two marine boiler explosions, one occurring on 26th June, 1875, on board the S. S. "Marcasite," the other on 1st July, 1875, on board the S. S. "Renown." In both these cases the steam domes were planted on cylindrical shells, secured thereto by flanging and a double line of rivets. In both cases the dome was blown off, rending all round at the base, the rent running through the inner line of rivet holes for the greater part of its course and through the solid metal at the root of the flanging for the remainder. The diameter of the domes in each case was about 4 ft. and the thickness of the plates $\frac{1}{2}$ in. The dome of the "Renown" blew off at about the ordinary working pressure of 65 lb., and that of the "Marcasite" at somewhat above the ordinary working pressure, but the exact amount is not known.

is owing not simply to the amount of metal cut away by the opening, but also to the action of the cover, which in unguarded manholes is generally internal. This internal cover bears on a narrow edge of plating all round, and is driven outward by the pressure of the steam, and also pulled in the same direction by the bolts in tightening the joint. In fact the cover acts as a sort of mandrel, which being forcibly driven through the manhole splits the boiler open. A heavy hydraulic test shows this action of the cover, by curling the boiler plate up around the manhole. Added to this, the joint is apt to leak, and thus to induce corrosion and thin the plate, which not only reduces its strength but leads to extra force being applied to tighten the joint; several explosions have occurred shortly after the joint has been re-made. It has been the general practice till recently to make raised mouthpieces of cast iron. This however is not wise for the high pressures now in use. A raised manhole mouthpiece having a clear opening of 16 in. diameter, which is the usual size, involves a hole in the shell plate at its base of about 20 in. diameter. The plate in which this hole is cut, unless it be duly strengthened, becomes the weakest part of the boiler when the longitudinal seams are double-riveted, the furnace-tubes suitably strengthened, with encircling rings, and the ends well stayed; so that the stability of the entire structure depends on the mouthpiece: if that fails, the whole structure fails. Under these circumstances it is evidently unwise to risk the safety of the boiler on a piece of cast iron. This view is confirmed by the behavior of cast-iron manhole mouthpieces under hydraulic pressure. Several have failed under the ordinary test at the boiler-maker's yard, while at one of the experimental bursting tests a cast-iron manhole mouthpiece of substantial pattern, measuring $1\frac{7}{8}$ in. thick in the lower flange and 1 in. in the body, rent at a pressure of 200 lb. per sq. in., though the metal exhibited a good sound fracture. This specimen is exhibited to the meeting. It would appear that under pressure there is a considerable upward strain on the plates around the mouthpiece; and that while wrought-iron mouthpieces are able to accommodate themselves to this without distress, cast-iron ones are not. These tests have shown that wrought-iron manhole mouthpieces are much superior to cast-iron, and that the sooner cast-iron ones are generally superseded by wrought-iron the better.

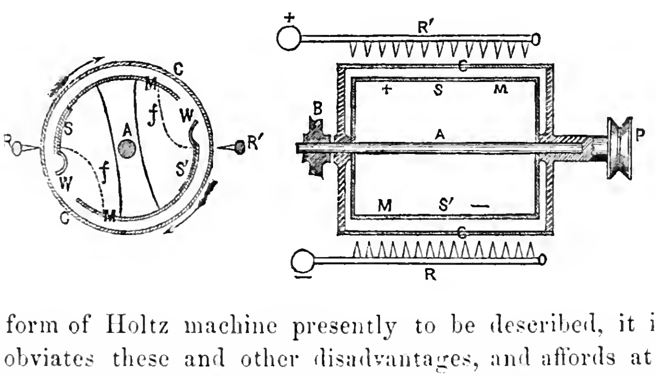
(To be continued.)

Chemistry, Physics, Technology, etc.

CYLINDER HOLTZ MACHINE.

By Prof. ELIHU THOMSON.

The many advantages possessed by induction electric machines, over those producing electricity by friction, have caused the latter to be almost entirely discarded as a source of static electricity. Of these induction machines, the "Holtz" is, perhaps, the best known, and many modifications of this machine have been designed to render it self-charging and constant in action. When, however, the plate form is adopted, the limit to the size of the revolving plates, with the ordinary materials and space that can be allotted, is soon reached. With glass plates the speed of running is limited by the fragile nature of the glass itself.



The form of Holtz machine presently to be described, it is believed, obviates these and other disadvantages, and affords at once a cheap, compact, and portable piece of electrical apparatus, capable of being run at a very high speed, and greatly increasing the electrical power of the machine.

The materials used in the construction are chiefly paraffined wood, and paper or cardboard, also paraffined. When wood or paper is thoroughly dried or baked, and, while still hot, immersed in melted paraffine at above 100° C. until soaked, it becomes, after cooling, one of the best non-conductors of electricity known. The wood so

treated is very strong, and will not subsequently warp or change its form. It is, so to speak, completely waterproofed.

In the figure, CC is a hollow revolving cylinder of paraffined paper or cardboard, the ends being made of the same material, or of wood similarly prepared. This cylinder is revolved about a *fixed* axis, A, by the pulley P. The axis A is fixed to the frame of the machine at B, and is made of paraffined wood or other insulating material. It serves as a support for the stationary inner cylinder MM, also of paraffined cardboard. The cylinder MM carries on its inner surface one or more pairs of what are commonly known as sectors or inductors, SS^1, consisting of strips of partially conducting material, placed opposite the outside rows of collecting points RR^1, and provided with the usual pointed projections turned towards the inner surface of the revolving cylinder CC. Parts of the inner cylinder MM, adjacent to the sectors SS^1, are cut away in a direction from SS^1 opposite to the direction of rotation of the outer cylinder. These open spaces are seen at WW. The open spaces or windows WW, are not necessary, if the contour of the inner cylinder be that shown by dotted lines f, f. The supports for the various parts as above described, are all thoroughly paraffined to ensure complete insulation. The metallic collecting points or combs RR^1 constitute the conductors or poles of the machine, + and — respectively, or the reverse, the polarity depending on the original charge given to the machine. The charging is accomplished by holding an electrified body, as a rubbed piece of caoutchouc or vulcanite, opposite one of the spaces or windows W, as shown at E, at the same time that the cylinder CC is in motion in the direction shown by the arrow.

The machine may be made self-charging by providing a small accessory cylinder, revolving opposite the points E, on an axis parallel to that of CC. The accessory cylinder is made of hard rubber, shellac, sulphur or the like, and is constantly rubbed by an amalgamated cushion, as in the common frictional machine.

A machine constructed as above, with the cylinder about 7 inches diameter and 12 inches long, and run at a moderate speed, gives enough electricity to charge three 1 gallon Leyden jars to a tension of 1 inch in less than four seconds, and may be employed for every purpose where an abundance of static electricity is required.

With a cylinder of 2 feet diameter, and 3 feet in length, it is possible to employ at least four rows of collecting points, each of which will be 30 inches long. A single revolving plate accommodating an equal length of collecting points, would require to be at least 7 feet in diameter. It is evident that the cylinder may be extended in length without adding seriously to its inconvenience.

The form of machine above described may be modified by placing the fixed cylinder and the sectors outside the revolving cylinder, the collecting points being inside the latter, and the conductors carried out at the extremities of the axis, but such an arrangement of parts possesses, it is thought, no peculiar advantages.

A machine constructed of revolving discs of paraffined paper or cardboard, instead of the ordinary plate, has been tried by the writer and was found to give excellent results. It would be quite possible to mount upon one axis a considerable number, say 50 plates or discs of cardboard properly prepared, which, with their corresponding *sectors* and collecting points, would furnish a machine of this character, which, for power, has never been equaled or even approached.

It may perhaps be interesting to remark that, since in the machine described, there is a direct conversion of mechanical energy into electric potential, if electricity be supplied to the machine, the cylinder, if sufficiently free to move, at once begins to turn in a contrary direction to that in which it would produce electricity.

HYDROGEN AND ITS SUBSTITUTES FOR THE LIME-LIGHT

From the *English Mechanic and World of Science*, London, Jan. 19th, 1877.

When making use of the lime-light recently, it occurred to us, says the *British Journal of Photography*, that pure hydrogen could be easily produced while the lantern exhibition was going on. This, we are very well aware, is no new idea, for it has already been referred to in articles in this journal. In the absence, however, of any special apparatus for this purpose, we extemporized a Woulfe's bottle of large dimension, into one neck of which we inserted a long glass tube terminating in a "bell" at the upper end. The bottle, having had several strips of zinc placed in a vertical position inside,

was made rather more than half full with diluted sulphuric acid, when a stream of hydrogen immediately rushed out. By carefully adjusting the emission of the gas a stream of great steadiness was obtained, and this, after passing through a drying-bottle, was conveyed to the burner, where it mixed with the oxygen and yielded an admirable light. From our experience we felt satisfied that with two of these bottles—one to take the place of the other while it is being re-charged with fresh liquid—a supply of hydrogen could be obtained under such pressure and in such quantity as to serve the purpose of an exhibition of several hours' duration. An improvement upon the Woulfe's bottle was afterwards secured in the adoption of a modified form of Döbereiner's lamp. This piece of apparatus, in its ordinary form, consists of a glass jar with a flat metallic cover, into which is cemented the neck of a flask without a bottom. When the jar is covered the flask reaches nearly down to its bottom; the upper end of the flask terminates in a stopcock, attached to which is a fine jet, and by means of a wire a piece of zinc is suspended inside the flask. When the outer vessel is nearly filled with diluted sulphuric acid, and the stopcock opened, the air in the flask is driven out, permitting the diluted acid to come in contact with the zinc, by which is caused an evolution of hydrogen filling the upper portion of the flask, in which it remains under pressure. This pressure, acting upon the surface of the liquid, forces it down beyond the zinc, upon which it has no further action until, by opening the tap and allowing the hydrogen to escape, the acidulated liquid is again enabled to rise in the flask and exercise its solvent action on the zinc, a continuous supply of hydrogen being thus obtained.

But the form of hydrogen-generator, which we found best, was one we had made of wood, lined inside with thin sheet lead, and which was on the same principle as the Döbereiner's lamp, although different in form. It consists of a square and oblong wooden box of the form and dimensions of a microscope case, for which it has more than once been mistaken. It is divided into two compartments by a partition from top to bottom; but, while this partition is soldered to the top and to each side, it does not come quite to the bottom, being distant from it to the extent of nearly a quarter of an inch. At one side of this box or vessel there is provided the means for throwing in scraps of zinc, and at the other a leaden pipe dips down through the top, almost reaching to the bottom. In the former division there is

provided at the top the means for attaching a pipe to convey away the gas. When diluted acid is poured into the vessel, hydrogen is liberated in great abundance in that division containing the zinc, and unless allowed to escape by the tap it exercises such pressure upon the liquid in that chamber as to drive it all into the other half of the vessel—a transition easily effected, as the lower edge of the partition does not quite touch the bottom.

By the length of the tube, or by the compression of the air in the other chamber, the pressure under which the hydrogen is to be emitted can be regulated with ease. Provision is also made to add either zinc or acid without interfering with the steady generating of the gas. It will be found advantageous not to place the partition in a vertical, but rather in a slanting. position. Guttapercha or vulcanite will answer quite well as material of which to construct the generator, although thin sheet lead, backed by wood, will prove more durable, as the diluted acid has no action upon this metal.

One caution we must here append: do not collect the hydrogen for use until all the air has been expelled from the upper part of the generator—a mixture of atmospheric air and hydrogen being explosive.

Electric Lighting.—Although the light now for some time in use in the Northern of France Railway station in Paris is economically obtained by means of the Gramme apparatus, there has been one point upon which improvement has been desired. A single light, as used in Paris, although placed at a great height, necessarily throws many very heavy shadows, which contrast most inconveniently with the blinding intensity of the light within its immediate neighborhood. The discomfort attending the brightness of the light has been somewhat relieved by glass shades, but the shadows are, although less severe, still inconvenient. It has hitherto been found impossible sufficiently to multiply the number of lights so as to avoid these defects, but a discovery has recently been made by M. Jablockhoff which seems destined to bring the electric light into common use. M. Denayrouse has brought the discovery before the Academy of Science, and it seems that it offers, with little extra cost, an efficient means of procuring several lights from one source of electricity, and of regulating the positions of the carbon points. The most delicate part of the electric light apparatus has been this adjustment of the distance

between the carbon points, and it is here that M. Jablockhoff steps in from quite a new path. Instead of placing the carbons end to end, he places them parallel with each other, and separated by some insulating material. The whole is then placed in a cylinder of refractory material in the form of a double carbon wicked candle. By this arrangement the two carbons burn by their lower extremity, there being no necessity for regulators, as the insulating material keeps them at a constant distance. This material as well as the cylinder is consumed in the same time as the carbons, its volatility augmenting the light. Previous to this discovery it was necessary to have a regulator for each lamp, and at great cost, but now a single source of electricity may feed a number of burners, thus permitting of the most effective distribution of the light.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS, DURING THE LAST TEN YEARS.[i]

By Dr. A. W. Hofmann.

From the *Chemical News.*

[Continued from Vol. ciii, page 72.]

As an interesting fact we may call to mind, that at the Paris Exhibition in 1867, large quantities of the silico-fluorides of sodium and barium, of soda-ash, and caustic soda were displayed by Tessié du Motay, as products obtained by the application of fluoride of silicon, and hydrofluo-silicic acid on the large scale. The hydrofluo-silicic acid was obtained by smelting silicic acid, fluorspar, and charcoal in a blast furnace, and receiving in water the fluoride of silicon contained in the flue gases,[ii] a process founded on the observations of Bredberg (1829), and Berthier (1835), and elaborated in its details by F. Bothe.[iii]

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i "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

ii Details concerning attempts at the industrial utilization of hydrofluo-silicic acid will be found in the article on the compounds of silica.

iii Bothe, *Wagner Jahresbericht*, 1868, 265.

Recently Christy and Bobrownicki [i] have taken out a patent in England, for obtaining ammonia from ammoniacal waters by means of hydrofluo-silicic acid. They precipitate the ammonia from such water by means of hydrofluo-silicic acid, and decompose the precipitate by means of quicklime without the application of heat. Whether this attempt to employ a siliceous compound in extensive chemical operations, will meet with a better fate than its predecessors, time alone must decide. It is the first mention of fluorine in chemical technological literature for the last five or six years.

The application of fluorides seem in fact to be dominated by some hostile influence. Even the use of hydrofluoric acid, for etching on glass, which appeared secure from rivalry, will probably experience considerable limitation in consequence of an American invention. B. C. Tilghmann [ii] uses for etching on glass, and other brittle materials, a jet of sand, violently projected against the surface of the object by means of a current of air, or of steam. (The details of this process are, of course, strictly mechanical.)

Against such a rival fluoric acid cannot possibly maintain its ground for etching, especially where large surfaces are concerned. It will be restricted to the production of fine, delicate designs, such as the graduation of measuring instruments.

The Sulphur Industry of Sicily.

Extracted from the Report of the Mining Engineer, LORENZO PARODI,[iii] by Dr. ANGELO BARBAGLIA, Professor of Chemistry at the Instituto Tecnico of Rome.

Sulphur is a widely diffused element, which occurs under the most various forms, both in the free and the combined state. In a free condition it forms rich deposits, which may be divided into two classes; such as are found on the surface of the earth in the neighborhood of extinct volcanoes (*solfatare*), forming earthy strata from 6 to 10 metres in thickness, saturated with sulphur, and underground beds (*solfare*), in which the sulphur is so intimately intermingled with the sedimentary rock, that it must be obtained by mining. The latter

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i *Ber. Chem. Gesell.*, 1873, 1322,

ii B. C. Tilghmann. The sand-blast for cutting hard bodies.

iii Sull estrazione dello solfo in Sicilia e sugli usi industriali del medesimo. Relazione dell ingegnère Lorenzo Parodi al Ministro d'agricultura, industria e commercia. Firenze, 1873.

deposits are the more important, and furnish nearly the whole of the sulphur of commerce.

Geology.—The most important sulphur deposits are those of Italy.[1] On the main land are the beds of the Romagna, which yield yearly 120,000 quintals of sulphur, those of Latera, in the province of Viterbo, and those of Scrofano. Beds of sulphur have also been recently found in the provinces of Volterra, Grosseto, and Avellino.

The true home of sulphur is Sicily, where the deposits extend over a great portion of the island, bounded on the south by the mountains Delle Madoni, and comprising almost the whole of the provinces of Caltanisetta and Girgenti, as well as a part of Catania, as far as Caltagirone, Rammacca, and Centuripe. Besides this there are isolated deposits at Lercara, in the province of Palermo, and at Gibellino, in the province of Trapani. The number of sulphur mines scattered in the above mentioned provinces is very considerable. According to a statistical conspectus for the year 1872 the number exceeded 250, with a total yearly production of 1,861,700 metric quintals, requiring an outlay of 2,472,935 lire.

Province.	Annual yield in Metric Quintals. Average of 1869, 1870, and 1871.	Expenditure in Italian Lire.
Caltanisetta, ...	781,400	1,263,390
Catania, ...	175,300	326,700
Girgenti, ...	826,200	763,645
Palermo, ...	78,800	118,200
	1,861,700	2,472,935

According to the recent, and highly interesting investigations of the mining engineer, Mottura, published in 1871, Sicilian sulphur is a product of the tertiary formation, and is found in the upper miocene between foliaceous crystalline gypsum and massive limestone (calcinari); its associates are bituminous marl (tufi) and gypsum. The sulphuriferous deposits (veins, courses, beds) vary exceedingly in inclination, thickness, extent, and in richness. In these deposits and on their outer boundary, there is invariably found a granular, friable, whitish rock, consisting chiefly of gypsum. The miners of

[1] This statement must be received with great doubts. It is probable that Iceland contains a very much larger quantity of sulphur than Italy.—*Ed. C. N.*

the island name this rock briscale, and suppose that from the purity and thickness which it displays on the surface they can infer the richness and extent of the sulphur deposits. The ores are divided into three groups:—

	Real Percentage.	Yield.
1. Richest, ...	30—40	20—25
2. Rich, ...	25—30	15—20
3. Ordinary, ...	20—25	10—15

Prospecting for Sulphur.—The existence of sulphur underground may be almost always concluded from characteristic indications on the surface. As such the *briscale* is especially regarded, and where it crops out to daylight it is a rule certain to lead to deposits of sulphur. The occurence of siliceous limestone and of sulphur springs are regarded as favorable indications. The first operation consists in driving strongly sloping adits, known by the native miners as *buchi* or *scaloni*. The latter name refers to the circumstance that they are laid out in stairlike flights, which are distinguished as *sani* and *rotti*, according as they run on in a right line, or turn off at an angle.

The Work in the Sulphur Mines.—The miners who raise the sulphur ores are called *picconieri*, and work under the direction of foremen known as *capo mastri*. At the head of the establishment, immediately under the proprietary, there is now generally a scientifically-trained mining engineer. The duty of the picconieri is to split out the sulphur ore from the veins, and to break it up, which is done with heavy hammers (*piccone*), weighing about 6 kilos., and sharpened on one side to facilitate the splitting. Gunpowder is very rarely used except where the gangue consists of the hardest limestone. The adits follow the direction and inclination of the veins, and branch out at places where the ore is rich and easy to work. In this manner are formed a series of spaces known as *gallerie* or *caverne* of every form and size opening into each other in the most various manner. The breadth of these galleries varies from 2 to 2½ metres; their height fluctuates and depends to a certain extent on the thickness of the beds, and especially on the hardness of the rock enclosing the sulphur ores. Where this rock is soft it would be dangerous to give the galleries a greater height than 2 metres, and to prevent accidents the sides are often supported by walls either run up dry or cemented with gypsum.

The 14 to 15 million quintals of ore furnished yearly by the 250 solfares of Sicily are almost exclusively transported by human labor. Both in the galleries and up to the mouth of the pit the mineral is carried by thousands of boys of from eight to ten years old (*manuali*), who convey the ore on their backs or shoulders. Only when the mine attains a depth exceeding 100 metres this method of transportation is abandoned, both in accordance with the sanitary laws and from economic considerations. At such depths, and especially when water has to be removed, machinery must be brought into play or the mine abandoned. In such cases horse-galleries (*gallerie di carreggiatura*) have long been employed in Sicily, but if water has to be lifted vertical shafts (*pozzi verticali*) become necessary.

(To be continued.)

Carbon Points for the Electric Light.—At a recent meeting of the French Academy, M. Archereau presented a new kind of carbon points for the electric light. They consist of agglomerated and compressed carbon mixed with magnesia; and according to M. Archereau they both render the light more stable, and increase its illuminating power, as compared with retort carbon points, in the ratio of 1·34 to 1. These carbon points are extremely hard, and burn without residue. They have been tried with the electric light produced by machines of the Alliance Company.

British Scientific Progress.—In a book recently published in China, the author, who has resided in England, accounts for British scientific progress by the fact that the English have undoubtedly robbed the Chinese of their learning. One method adopted by English scientists, has been the making of an extract from the eyes of Chinese who have become Christians, and touching the eyes of foreigners with it, by which they have been enabled to understand astronomy, and perceive the mineral wealth of the earth. Another valuable medicine for the promotion of intelligence has had, for one of its ingredients, the brains of a Chinese girl who had embraced Christianity. Other medicines have been mixed with the brains, and the compound made up into pills, which received their final touch in the shape of incantations instead of sugar-coating.

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FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

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EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Committee on Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Franklin Institute.

HALL OF THE INSTITUTE, March 21st, 1877.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 119 members and 12 visitors.

The minutes of the last meeting were read and approved.

The minutes of the Board of Managers were presented, showing that at its last meeting 19 persons were elected members of the Institute and the following donations made to the library:

Specifications and drawings of Patents for September, 1876. From the U. S. Patent Office.

Annual report of the St. Louis Mercantile Library Association. 1876. From the Association.

Report of the Western Railroad Association for 1876. From the Association.

New Encyclopædia of Chemistry. Pts. 15—20. From J. B. Lippincott & Co., Publishers, Philad'a.

Index to the catalogue of the ordnance collection. Washington, 1876.

Military Bridge equipage, designed and constructed by V. Norrman. Philad'a, 1876.

Swiss catalogue of the International Exhibition in Philadelphia, 1876.

Swedish catalogue: 1, Statistics; 2, Exhibits, International Exhibition, 1876, Philadelphia.

The exhibition of the Geological survey of Sweden at the exhibition at Philadelphia, 1876.

Surahammars Bruks Aktiebolay Sverige. Stockholm, 1876.

Mechanico therapeutic institution in Stockholm, by G. Zander. Philad'a, 1876.

Description of hydrographical and meteorological instruments exhibited at the Philadelphia Exhibition, Philad'a, 1876. Stockholm.

On the state of the Iron manufacture in Sweden at the beginning of 1876, by R. Ackerman. Stockholm, 1876.

Synopsis of the Christian Hammer's Museum of Art and Antiquity. Stockholm. From the Swedish Commission.

Catalogue of Canadian exhibitors at the International Exhibition, Philad'a. Montreal, 1876.

Manitoba and the North West of the Dominion, its resources and advantages, by T. Spence.

Dominion of Canada, Province of Ontario. Catalogue of exhibits in Education department, Centennial Exhibition, Philad'a. Toronto, 1876. From the Canadian Commission.

Woods and minerals of New Brunswick. Descriptive catalogue prepared for Centennial Exhibition, Philad'a, 1876. Frederickton, N. B., 1876.

Memoir on the novel formation of the bottom of ships and vessels, proposed by the Brazilian naval architect, Trajano A. de Carvalho. Philad'a, 1876.

Brazilian section, Machinery Hall. Notice on the models of ships, exhibited by the Rio de Janeiro Navy Yard, Philad'a International Exhibition, Philad'a, 1876.

Catalogue of the Russian section, International Exhibition of 1876, at Philadelphia. St. Petersburg, 1876.

Description of the collections of Scientific appliances instituted for the study of mechanical art in the workshops of the imperial technical school of Moscow. 1876.

From the Russian Commission.

International Exhibition, 1876. Official Catalogue, Main Building. Pts. 1 and 2. Philad'a, 1876.

Corporation, "The Artisan's school, Rotterdam, Holland, established in 1869."

German department. Official Catalogue. Berlin, 1876.

Bessemer steel, exhibited by Fagersta Bruk, at the Intern. Exhibition, Philad'a, 1876.

International-Ausstellung in Philadelphia, 1876. Das Unterrichtsschul- und Bildungswesen der Schweizerischen Abtheilung. St. Gallen, 1876. From the German Commission.

Special Catalogue of the Netherlands section, edited by authority of the Royal Commission of the Netherlands, International Exhibition, Philad'a, 1876.

Kirkaldy's experimental inquiry into the mechanical properties of Fagersta steel. London, 1876.

Second preliminary report on the mineralogy of Pennsylvania, by F. A. Genth, with analyses of mineral spring waters. From F. A. Genth.

Columbia College School of Mines, Catalogue of the officers and students, for the year 1876-7. From the College.

Illustrated catalogue and manual, improved engineering instruments. From Buff & Berger, makers.

Annual report of the Chief of Engineers to the Secretary of War, for the year 1876. In 3 parts. From the Chief of Engineers.

Annual report of the Board of Directors of the Pennsylvania Institution for the Deaf and Dumb, for the year 1876. From Wm. Welsh.

Proceedings and Transactions of the Nova Scotian Institute of Natural Science, of Halifax, Nova Scotia. Vol. 4. 1875–76. Pt. 2. From the Institute.

Annual report of the Secretary of the Treasury on the state of the finances, for the year 1876. From the Treasury Department.

British patent specifications issued from August 5th to December 30th, 1876. British patent abridgments on artificial leather, 1627-1866. Wearing apparel. Div. 4. Dress fastenings and Jewelry, 1631-1866. Agriculture. Div. 1. Field implements, 1618-1866. Trunks, portmanteaus, etc. 1835-1866. Victoria patents and patentees. Vol. 8. Indexes for the year 1873, by Richard Gibbs, Registrar General. From the Patent Office.

Annual reports of the operations of the U. S. Life Saving Service, for the fiscal year ending June 30, 1876. From the Treasury Department.

Silk industry in America. A history prepared for the Centennial Exhibition, by L. P. Brockett, 1876. From F. O. Horstmann.

Report on the salt manufacture of Michigan, by S. S. Garrigues. State salt insp. · N. Y., 1876. From the author.

An essay on New South Wales, by G. H. Reid. Sydney, 1876.

Three papers on heat and combustion, read before the Railway Polytechnic Society of Cleveland, Ohio, by P. H. Dudley, C. E. From the author.

Ritchie's catalogue of philosophical apparatus. Boston, 1875. From E. S. Ritchie & Sons.

American Journal of Microscopy and popular science. Vol. 1. N. Y., 1876. From the editor.

The Committee on Primary Industrial Education presented a partial report which was read,[1] and was followed by an animated discussion by a considerable number of members, when on motion of Mr. Whitney, it was

Resolved, That the chairman of the committee be authorized to have printed not more than 1200 copies of the report, and that one be sent to each member of the Board of Education.

Mr. R. Bingham, of Camden, was then introduced, and read the paper announced for the evening, on Useful Education.

The Secretary presented his report, embracing Edgerton's self-condensing Gasholders, with safety arrangement; Zuccato's Papyrograph for printing autograph letters or circulars; the Fowler Fly fan; the Cascade Evaporator for hot air registers; John McConn's rock expansion joint, and some new experiments with a modified Atwood falling machine by Mr. J. W. Nystrom.

Mr. J. J. Weaver offered the following preamble and resolutions, which, on motion of Mr. Cartwright, were postponed to the next meeting:

Whereas, Whatever tends to improve the condition of the skilled mechanic, and aids in bringing him to the notice of those requiring his services when necessary, is clearly within the province of the Franklin Institute, viz.: "The promotion of the mechanic arts," therefore be it

Resolved, That the Secretary be directed to provide a book, in which he shall enter the names, occupations, references, etc., of those members of the Institute who may report themselves to him as being out of, and desiring employment; and that the Secretary shall have printed upon the monthly notices, sent to each and every member of the Institute, the *occupation only* of those who have so reported to him.

Resolved, That those members who may require the services of such, shall be furnished with detailed information only by personal

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[1] See page 221.

application to the Secretary; the Secretary to give information touching the special occupation in which the member applying is interested, and none other.

The President announced that he had appointed the following members on the standing committees of the Institute for the current year:

On Library.—Chas. Bullock, Saml. Sartain, W. P. Tatham, Jos. M. Wilson, Pliny E. Chase, Robert Briggs, J. B. Knight, E. J. Houston, J. W. Nystrom, Dr. Isaac Norris, Jr.

On Minerals.—Dr. F. A. Genth, Theo. D. Rand, Clarence Bement, Persifor Frazer, Jr., Dr. W. H. Wahl, E. J. Houston, Otto Luthy, Robert Grimshaw, E. F. Moody, Dr. G. A. Kœnig.

On Meteorology.—Pliny E. Chase, Hector Orr, Dr. Isaac Norris, Jr., John Wise, J. E. Mitchell, Jas. A. Kirkpatrick, David Brooks, Alex. Purves, Dr. W. H. Wahl.

On Models—H. L. Butler, Edward Brown, M. L. Orum, J. Gœhring, L. L. Cheney, J. J. Weaver, C. Chabot, J. B. Knight, S. Lloyd Wiegand, A. G. Busby.

On Arts and Manufactures.—J. J. Weaver, Geo. V. Cresson, Hector Orr, Coleman Sellers, Jr., W. B. LeVan, Wm. Helme, H. W. Bartol, J. S. Bancroft, Alfred Mellor, Cyrus Chambers, Jr.

On Meetings.—H. Cartwright, Saml. Sartain, Washington Jones, J. B. Knight, C. S. Close, P. E. Chase, W. P. Tatham, L. M. Haupt, W. L. Dubois.

On motion, the meeting adjourned.

J. B. Knight, *Secretary.*

REPORT OF COMMITTEE ON PRIMARY INDUSTRIAL EDUCATION.

The Committee of the Franklin Institute appointed to consider certain alleged defects in the education of children in public schools and private seminaries, by which the true dignity of labor is impaired, and there is an absence of special preparation for mechanical and other useful arts, makes the following partial report:

Your Committee, after a personal inspection of public schools and conferences with their teachers, directors, and the Board of Education, has become satisfied that whilst the instruction, in almost all of these schools, is very defective in the particulars referred to, yet there is a general disposition to make the instruction more practical, that the children may be prepared for earning a livelihood by industrial pursuits.

The point to which your Committee has thus far more particularly directed its investigation, is that of "object teaching," which has been followed by very satisfactory results in schools where introduced. The importance of this system is acknowledged by all who have had the opportunity of witnessing a fair trial, and we think it only necessary to bring it fully before those having authority, to secure its enforcement in all the schools of the city.

The old system of instruction is based upon the supposition that mental power can be increased most effectively by memorizing words, and by grappling with abstract ideas. This system is, no doubt, adapted to some mature minds of extraordinary power, and possibly in a very few cases to the young, but not to the many.

The great advantage of object teaching is that it cultivates the perceptive faculties and quickens the observation, leading the mind from the object to its name and uses, which is certainly the natural course of learning. By this means the subject of the lesson is first fixed in the mind, then an interest is developed from a natural curiosity, and finally there grows up a love of study.

On the contrary, under the old system all the child learns is from an effort of the memory only, the abstract names having no association with visible things, and the explanation of their properties and uses being simply so many sentences to be memorized, without any appreciation of their meaning.

Thus, by the objective system, the child not only learns more quickly and thoroughly the lesson given it, but it is also taught how to learn. In fact, what is called objective teaching in the primary schools, is precisely what is done in the higher departments, where the students have illustrated lectures and the use of apparatus for practice in laboratories. All our great institutions of learning spend large sums of money in the purchase of such apparatus, and for no other reason than an appreciation of the immense advantages to be derived from having before the students the object to illustrate the principles being taught.

If so great benefits are derived from this method in the case of advanced students, where the mind has already been trained to some extent to methods of thought, how much more important is it with the child who has still to learn the true use of its perceptive faculties, and needs that development of its reasoning powers which will enable it to grapple with abstract principles. Under any of the

approved systems of object teaching, the happiness and health of the child are better maintained, for much more attention is given to physical exercise, thus leaving it better able to withstand the strain of more advanced studies when reached.

One of the greatest difficulties to be encountered in effecting any change in the system of teaching, must naturally be the want of the necessary training on the part of the teachers, and in order to overcome this difficulty, a school of practice was organized on the first of January last in connection with the Girls' Normal school. This school is organized on exactly the same plan as other public schools: it numbers six primary and four secondary divisions, and is supplied with a complete outfit of material for the most approved system of object teaching. The pupils are instructed by those of the graduating class of the Normal school alternately, under the direction of a principal, elected for that purpose. Here, children from six to seven years old, become practically familiar with weights and measures, and acquire remarkable skill in drawing on the blackboard the sizes and shapes of objects, while describing their nature and uses.

This school of practice will enable a fair comparison to be made between the two systems, as the pupils are drawn from that portion of the city convenient to the school, and from among those who attend the regular primary schools.

Thus the graduates of the Normal school—a large portion of whom are expected to become teachers—will be familiar with the system of object teaching and its advantages, and as the success of any educational system depends largely on the teachers, they cannot fail to have a great influence in improving that of our city.

This school of practice is under the immediate direction of the Board of Education, a majority of which manifest a strong desire to extend the same system of teaching throughout the city. This Board several years since placed object teaching on the schedule of instruction, to be given in all the Public schools of this city. To this time, so far as your Committee has been informed, some of the schools in the Eighth Ward have alone complied with this requirement of the Board of Education. Many members of the Teachers' Association are also anxious to see object teaching, including drawing, and other practical instruction, universally taught. In this respect several of the other large cities are much in advance of Philadelphia, as they have Superintendents and Assistant Superintendents of Public

Instruction, through whose agency these improvements have been made. In Pennsylvania, the instruction outside of Philadelphia is under the direction of J. P. Wickersham, the Superintendent of Public schools, who cordially supports the views of your Committee.

The public schools in Philadelphia, although under the general direction of the Board of Education, are controlled by directors elected in each ward. Your Committee has resolved to convene first the teachers and then the directors in the lecture room of the Franklin Institute, with the hope that a personal conference will influence them to give the children in their respective schools and wards the advantage of a practical preparation for industrial pursuits.

The subject of teaching drawing in the public schools has had as yet but limited consideration, but your Committee is satisfied of its great importance, as preparing the pupil for instruction in every useful art—whether as an apprentice, or as a pupil in some industrial or technical school.

This subject, as well as that of industrial and technical schools, will be considered more fully in a future report.

WM. WELSH, *Chairman.*

Donations continued from March Number.

Report on the transportation route along the Wisconsin and Fox rivers, in the state of Wisconsin, etc., by G. K. Warren. Washington, 1876. From the author.

Annual report of the board of regents of the Smithsonian institution, for 1875. Washington, 1876. From the Institution.

Report of the Commissioner of Agriculture, for 1875. From the Department.

Lectures delivered on Iron Metallurgy, by I. R. de Ibarrola, C.E., Mexican Society of Civil Engineers and Architects. (Two copies) on a translation. From the Society.

Plan of steam, water and sewer pipes in Machinery Building and annexes, Philadelphia International Exhibition, 1876. From John S. Albert, Chief of Bureau.

Brewers' Industrial Exhibition, Centennial Grounds, Fairmount Park, Philadelphia. Essays on the malt liquor question. New York, 1876.

General account of the Commonwealth of Kentucky, prepared by the Geological Survey of the Commonwealth, for the Centennial Exhibition at Philadelphia, 1876. Cambridge, 1876.

Catalogue of products of Michigan in the Centennial Exhibition of all nations at Fairmount Park, Philadelphia. Lansing, 1876.

The use of the Steam Engine Indicator. By E. Lyman, C.E. New Haven, 1874.

Rules for the construction, inspection and characterization of sail and steam vessels. Buffalo, 1876.

Test of power required for cotton and other machinery, by dynamometer belonging to the Amoskeag Manufacturing Company, etc. By Samuel Weber, C.E., 1874.

Chemin de fer de l'état, Postes, Telegraphes, Marine, etc., etc. Bruxelles, 1875.

Australian Orchids, Sarcochiles Divitiflorces, by R. D. Fitzgerald, F.L.S., Sydney.

From the Authors, through the Reception Room of Franklin Institute at International Exhibition, Philadelphia, 1876.

Catalogue of the Chinese imperial maritime customs' collection, at the U. S International Exhibition, Philadelphia, 1876. Shanghai, 1876.

International Exhibition, 1876, special catalogues of stated displays of live stock. Part I, Horses; Part II, Dogs; Neat Cattle, Sheep and Goats, Part I; Swine, Part II. Also special catalogue of the display of poultry, Oct. 27th to Nov. 6th, 1876. Philadelphia.

Norwegian special catalogue for the International Exhibition at Philadelphia, 1876. Christiania, 1876.

International Exhibition, 1876, at Philadelphia, Portuguese special catalogue. Departments 1–5, Mining and Metallurgy, Manufactures, Education and Science, Fine Arts, Machinery.

Agricultural Hall, ground plan showing passage ways, and spaces for installation of exhibits, No. 1. Half transverse sections of the same building.

Art Gallery and plans of extension to the same.

Horticultural Hall and plan of same.

Machinery Hall, etc., plans of Hall and Boiler Houses. Drawings of plans of steam, water and sewer pipes in Hall and Annexes.

Main Building, installation plan and plans of sections, etc.

Plans of Fairmount Park, Exhibition Grounds, etc. From P. C. De Sauque, Philadelphia.

Annual report of the board of regents of the Smithsonian institutions, etc., for the year 1875. Washington, 1876.

The Empire of Brazil at the universal exhibition of 1876, in Philadelphia.

Smithsonian contributions to knowledge, Vols. 20 and 21. Washington, 1876. From Smithsonian Institution.

Treatise on machine tools, etc., etc., as made by Wm. Sellers & Co., Philadelphia, Pennsylvania. From Wm. Sellers & Co.

Centennial Passenger Traffic of the Pennsylvania Railroad.—The following is extracted from the thirtieth annual report of the company, just issued:

In order to accommodate the immense passenger traffic of the Centennial year, it was necessary to make important changes in the system of tracks in the West Philadelphia yards and at the new Centennial station, all of which were accomplished in time to meet the requirements of the Company. A large passenger station was built immediately opposite the main entrance to the Centennial grounds, and the tracks for the incoming and outgoing trains were constructed in the form of a circle, so that there could be a continuous arrival and departure of trains without interference. This plan worked most satisfactorily; the risk of collisions or other accidents to trains was avoided, and the Company was not only enabled to provide for the increased number of trains over its own lines, but to furnish accommodations for the North Pennsylvania and Bound Brook Lines, and for the Philadelphia, Wilmington and Baltimore Railroad. The movement of all passenger and freight trains, to and from the Centennial Grounds and the station at West Philadelphia, was placed under the immediate charge of Charles E. Pugh, with a sufficient corps of officers under him to take prompt care of the great concentration of traffic at those points.

During the Centennial season, between the 10th of May and the 10th of November, 20,231 passenger trains, with 127,296 cars, and 2,343,499 passengers, arrived at the West Philadelphia Station, Thirty-second and Market streets, and during the same period 22,372 trains, with 141,284 cars, and 2,612,213 passengers, arrived at the Centennial Station, making a total of 42,603 trains, with 268,580 cars, and 4,955,712 passengers. This large movement was accomplished without the slightest injury to any passenger. During the period referred to, 90 per cent. of this whole amount of passenger traffic was handled between the hours of 7 and 11 o'clock in the morning, and 4 and 7 o'clock in the afternoon.

The total amount of baggage received and delivered at the West Philadelphia, Centennial, Kensington and Market Street Ferry Stations, was 730,486 pieces, and of this aggregate but 26 pieces were lost or mislaid, the claims for which, as presented, amounting to the small sum of $1906.99.

It is believed that the volume of the passenger and freight traffic of the lines controlled and operated by the Pennsylvania Railroad Company during the Centennial season was largely in excess of that ever handled by any other company. Its careful and successful movement reflects the highest credit upon the General Manager, and the officers under his charge on the various divisions of the line.

A New Method of Synchronizing Clocks.—A new method of synchronizing clocks has been introduced by Messrs. Barraud and Lund, of Cornhill, who have had granted them by the Post-office authorities the special use of a system of wires for working it. A narrow slit cut in the dial of a clock admits two projecting pins. They are arranged so as to catch the minute hand at given intervals, and to set the clock to true time. The pins, attached to a pair of slotted levers, connect with an electro-magnet. The mechanism required can easily be screwed into its place, and it remains entirely disconnected from the works of the clock. Any number of clocks varying in size and calibre can, on receipt of one time signal, be simultaneously set to accord with each other in accurately denoting Greenwich time. The Bankers' Clearing House immediately availed themselves of the advantages of a system, which will remove the often recurring disputes as to "paying in" within the specified time. Other City Establishments will be provided with the apparatus as soon as the Post-office employees are enabled to extend the requisite facilities. The invention must prove a great boon for all mercantile men, and for railway travelers, etc.

Browning of Iron.[1]—By P. Hess (*Dingl. polyt. J.*, ccxxi, 94—95).—The surface of the iron is painted over with linseed oil and heated, whereby, together with separated carbon, ferroso-ferric oxide appears to be produced, which forms the essential protecting layer. Articles which cannot be heated may be dipped into an acidulated solution of ferric chloride, whereby a black layer of ferroso-ferric oxide is formed, which, when dipped into hot water, becomes firmly fixed on the iron, so that after drying it can be rubbed with linseed oil. The formation of this layer takes place by the reducing action of the iron on the oxide and its salts:

$$4Fe_2O_3 + Fe = 3F_3O_4.$$

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[1] Abstracts of Chemical Papers, from the *Journal of the Chemical Society*, for January, 1877.

The advantages of browning with ferroso-ferric oxide (magnetic iron ore or smithy scale browning), consist in the fact that it is done much more quickly than the browning with ferric oxide, and that it is more beneficial to the iron than the latter. By using cuprous sulphide a fine bluish-black layer is obtained, which forms a good protection against rusting. The iron has only to be placed in a solution of cupric sulphate for a few minutes, until a fine copper coating is formed on its surface, which, after having been washed with water, is treated with a solution of sodium hyposulphite (thiosulphate) slightly acidulated with hydrochloric acid, when a bluish-black coating of cuprous sulphide is obtained, which is unaffected by air and water. The surface is then washed with water, dried, and polished.

Artificial Lighting of Rooms.—The artificial lighting of rooms affects the human system, on the one hand, through the change produced in the composition of the air by gases of combustion, and on the other through rise of temperature. These influences have lately been examined by M. Erismann (*Zeitschrift fur Biologie*). In a part of the laboratory 10 cubic metres' capacity, inclosed by wooden and glass walls, various materials were burnt eight hours, viz., stearine candles (six at a time), rape oil, petroleum, and ordinary gas, and the air was drawn off at different heights and analyzed. The results do not pretend to absolute exactness, but a comparison of them is interesting. The tables first show that under all circumstances, and with all sorts of artificial lighting, the air of an inclosed space contains more carbonic acid and organic carbon-containing substances than in absence of such illumination; still, in these experiments the carbonic acid was never greater than 0·6 or 0·7 per 1000, while the proportion of other carbon compounds was very variable, so that the amount of carbonic acid gives no exact criterion for the vitiation of the air. The CO_2 actually found in the air was only a very small fraction of that produced by the combustion; by far the greatest part must have been carried away by the natural ventilation. In comparing the four materials, the proportion of CO_2 and other carbon compounds was reduced to a light strength of six normal candles. It appeared that the petroleum, with lamp of good construction, communicates to the atmosphere, not only less CO_2, but (what is much more important) fewer products of imperfect combustion than the other lighting mate-

rials; and, further, that stearine candles, with the same light-strength, vitiate the air most. As to temperature, that of the lower layers of air, up to a height of 1·5 metres, rose very little during the eight hours, about 2° to 3° on an average, while the upper layers increased considerably in temperature, especially just under the ceiling; this increase, in the case of ordinary gas, rape oil, and petroleum, was 10·5° to 10·8°, in that of candles only 4°. If, however, we take into account the photometric light-effect of the flames during the experiment, it is found that, with equal light-strength, rape oil and gas raise the temperature considerably more than petroleum, and the action of the latter, indeed, came to about that of the candles.—*Nature.*

Industrial Society of Mulhouse.—The number of boilers submitted to the control of the Society in 1876, was 1470, an increase of 138 over the previous year. The change of officers, the installation of new engineers, the necessity of more thoroughly organizing the visiting bureau, and the May Exposition, have interfered somewhat with the trials of machines, but an increased activity is anticipated for the current year, especially in experiments upon the consumption of fuel by different types of motors. The great metallurgical establishments in the neighborhood of Metz, have called for the maintenance of a permanent inspector at that place, and another is to be installed at Strasburg, in order to secure a more regular service for the subscribers in the Lower Rhine district. The number of tests with Watt's Indicator has been 91; with the hydraulic press, 349. Though about 70 serious defects have been discovered, there have been only two accidents. The first was the explosion of an interior tube of a generator, in the establishment of one of the members of the Association in the Grand Duchy of Baden, by which one man was seriously wounded. The explosion was occasioned by a deficiency of water, the night and day watchmen having each neglected to try the gauges at the morning change of watch. The second accident was the suffocation of a workman by ammoniacal and sulphurous vapors. The instruction in the School of Design has been made gratuitous. During the year, 99 pupils of ages varying from 13 to 19 years, have been in attendance, and a number of applicants have been obliged to wait for vacancies, on account of want of room.—*Bulletin de la Soc. Ind. de Mulhouse*, Supplement, Dec., 1876. C.

Cost of Street Cleaning in Paris.—The total cost is about 5,000,000 fr., viz.: Agents, drivers and overseers, 260,000 fr.; implements and disinfectants, 250,000 fr.; sweeping, 2,920,000 fr.; removal of snow, ice and filth, 908,000 fr.; sprinkling, 450,000 fr.; heating offices and miscellaneous expenses, 80,000 fr.—*Annales des Ponts et Chaussées*, January, 1877. C.

Use of Magnesia in Clarifying Sugar.—Sres. Bernard and Ehrman find that the alkalinity of magnesia, and its insolubility in saccharine liquors, fit it for the defecation of fermented cane juice. With a dose of from 3 to 5-thousandths the clarification is complete, and the juice is easily filtered. Any excess of magnesia remains in the scum. Laboratory experiments show an increase of 6 to 7 per cent. in the yield of white sugar, while the quality is not inferior to the best commercial brands. Experiments are to be tried on a larger scale, in order to determine whether magnesia can be economically used in all refineries.—*La Gaceta Industrial*, Jan. 10, 1877. C.

Iridescent Glass.—MM. E. Fremy and Clémandot submit glass, under the influence of heat and pressure, to the action of water containing about 15 per cent. of chlorhydric acid. This produces a permanent pearly lustre which, they believe, will be found a valuable addition to the ornamental processes now employed in glass factories. —*Les Mondes*, Feb. 8; *Acad. Sci.*, Jan. 29. C.

Rotary Magnetic Polarization.—M. Fizeau recommends the insertion in the *Recueil des savants étrangers*, of M. Henry Becquerel's memoir on the above subject. The memoir contains new experimental investigations of the phenomena discovered by Faraday, in 1865, and described by him under the title of "Magnetization of Light."—*Les Mondes*, Feb. 8. C.

Formation of Sulphur Springs.—M. E. Plaugaud found, near the source of a mineral spring which was strongly impregnated with sulphur, a number of fine confervæ, which he washed carefully and left in a flagon of ordinary water. About eight days afterwards, wishing to re-examine them, he was struck with the strong sulphurous odor which escaped from the water. He then instituted experiments, which led him to the following, among other, conclusions: 1. Sulphurous mineral waters owe their formation to the reduction of divers sulphates, under the influence of living bodies, which act as ferments. 2. It is still to be seen whether the sulphuration of the water arises

in any case, without the intervention of ferments. Acetic acid, which is commonly formed under the influence of *mycoderma aceti*, may be produced by platinum sponge; and, in like manner, sulphates may be reduced through a variety of influences.—*Ibid.* C.

Carbonic Acid in Air.—The open air commonly contains about 3·34 parts, by volume, out of 10,000; according to Pettenkofer any excess over 1 part in 1000 is unwholesome. E. Schulze (*Archiv. der Pharmacie*, 1876, v. 209, p. 412) thinks Pettenkofer's limit is too low. In a club room he found 37 parts of carbonic acid, and in a school room from 14·4 to 35·6 parts out of 10,000.—*Dingler's Polyt. Journal*, 223, 2, Jan., 1877. C.

Star-twinkling in Damp Air.—Humboldt observed that in tropical regions the approach of rain is often announced by the twinkling of stars near the zenith. Montigny (Bulletin de l'Académie royale de Belgique, 1876, v. 42, p. 255), observed the intensity of the twinkling for 230 evenings, and found that it increased if a storm or a barometric depression was approaching. When rain is foreboded the glimmer is especially strong.—*Ibid.*

Proposed Improvements in Venice.—Among the engineering projects of "New Italy," is one of Giovanni Antonio Romano, for restoring, at least in some measure, the commercial prestige of Venice. His plan embraces an extension of the railway to the eastern extremity of the island La Giudeeca, the building of moles, embankments, wharves, storehouses, yards, docks, stations for passengers and freight, and the union of the State, the Venetian Commune and the Chamber of Commerce, in joint guarantees of bonds for construction, as well as in equable division of the revenues. He represents Venice as the most accessible port for Switzerland and Western Germany, while it might reasonably hope to compete successfully for a large part of the commerce of Eastern Germany. If proper arrangements are made for deepening the channels and keeping them clear, the double approach by Malamocco and by S. Nicolo di Lido, will make the harbor one of the most accessible as well as one of the best in the world. Commercial enterprise, combined with a judicious and liberal policy in the removal of restrictions and in furnishing facilities for trading vessels, ought to invite to such a harbor a large traffic with America, Asia, Africa and Central Europe.—*Il Politecnico*, Dec., 1876. C.

Book Notice.

THE ART OF PROJECTING.—By Prof. A. E. Dolbear. 8vo, pp. 158. Boston, Lee & Shepard. For sale by J. B. Lippincott & Co., Philadelphia.

The author of this little work has very thoroughly accomplished the object, as expressed in the preface, of pointing out to teachers of physical science, and to others who may be interested in experimentation, the usefulness of the magic lantern, and especially of the Porte Lumière and a few other pieces of apparatus which can mostly be extemporized.

This work describes and illustrates a large number of experiments in the department of general physics, acoustics, light, heat, etc., which can be projected on the screen with moderately simple apparatus.

No attempt being made to explain phenomena, there is an absence of technicalities, which, with the clearness of description, aided by ample illustrations, makes it well adapted to the use of amateurs, without impairing its value for the use of teachers. The apparatus and methods described are generally those adopted by eminent experimenters, and are with few exceptions the best. As one of these exceptions, may be noticed the animalcule cage pictured on page 33. This is inexpensive and easily made, but must prove unsatisfactory in use, while those devised by Mr. D. S. Holman, and known as the life and the siphon slides, are so much superior as to have warranted their being mentioned.

In speaking of ice flowers on page 52, it is stated that to exhibit them on the screen it is necessary that the beam of light should consist of parallel rays, and that the block of ice should be one-half to three-quarters of an inch thick. Both these statements are erroneous; much better results are obtained by having the piece of ice quite thin, say less than one-quarter of an inch thick, taking care that it is kept at as low a temperature as possible before using.

The intensity of the illumination and consequent brightness of the pictures, are obtained by using a converging beam of light, and placing the piece of ice near where the rays cross. If these conditions are carefully observed, quite clear, well-defined pictures can be obtained.

The wide field covered, and the care with which it is prepared, make this book deserving of a place in the hands of all interested in illustrations of this character. K.

Civil and Mechanical Engineering.

ON THE LOSS OF HEAT BY RADIATION FROM STEAM BOILERS, AND THE ECONOMIC VALUE OF BOILER CLOTHING.

By J. C. Hoadley.

That heat escapes rapidly by radiation from the outside of steam boilers containing steam of high pressure, when the surface is unprotected, is familiar to all. That clothing or covering with wood, or felt, or with a cement of asbestos, gypsum, or some other feeble conductor of heat, lowers the temperature exposed to the air, and so diminishes the loss by radiation, is also well known.

What is not so generally known, or so accessible, if the knowledge exist at all, is the exact ratio of loss under certain definite conditions, such as we often meet in practice, and the economic value of certain admissible kinds of clothing. The saving effected by clothing boilers, pipes and other vessels containing steam, cannot be considered as inversely proportioned to the conducting power of the material used for clothing. The outer surface is more or less enlarged, and radiation, if less active, goes out from the enlarged surface. If the material of the outer covering be a better radiator than iron, as it will be of necessity if a poorer conductor, the loss may be very great while the radiating surface feels only moderately warm to the hand. Just what the loss is in a given boiler under familiar conditions, what ratio this loss bears to the steam generating power of the boiler, and what saving can be effected by clothing of some convenient kind, are facts not generally known, and such data as have been established by observation and experiment, are neither very accessible nor easily applied in practice.

Nearly all boilers of much importance in use for stationary purposes, are effectively protected by brickwork, with ashes or other similar material on top. Locomotives, exposed as they are to all the rigors of the elements, to wind, snow and rain, have usually something more than half of their exterior in some degree protected with a covering, generally of wood, cased with sheet iron.

Portable steam engines are, in England, almost universally covered about as locomotives are. The waist, or barrel, is generally covered while the fire-box casing is usually left naked. In this country, any covering at all is the rare exception.

Having had on exhibition (in use) at the International Exhibition in Philadelphia, an engine of the class styled in England "semi-portable," or self-contained, but usually classed in this country among "portable engines," and having had this engine (14·5″ × 20″) tested for economy in September last, I was led to make some experiments to ascertain the extent of loss to which the boiler would be subject by reason of its exposure, entirely naked, to the air of the engine-room, the radiating surface being equal to about two-fifths of the heating surface.

These experiments twice repeated, gave, at the more useful pressures—90 to 120 pounds above atmosphere—a loss of 9 to 11 per cent. of the steam generating power of the boiler as usually fired for its normal work, about 80 h. p. It was still a matter of doubt how far this loss could be reduced by any practicable method of clothing; and the importance of the subject, and the interest awakened by the experiments above mentioned, induced me to carry the investigation further at the first opportunity. Such an opportunity soon offered. We were making a portable engine of sixty horse power for Messrs. William Sellers & Co., for use in a mill of which they are proprietors, at a short distance from Philadelphia, and, by agreement, the boiler was to be covered.

Experiments on radiation were carefully made, first, before clothing the boiler, and again afterwards, with results exhibited on the accompanying diagram, which, together with the manner of conducting the experiments, will be explained somewhat in detail.

The boiler having been tested and found to be tight with 150 lbs. pressure by steam gauge, steam was reduced to atmospheric pressure, with water at about normal water line ($2\frac{1}{2}$ in. above top of crown sheet), and a good fire of dry wood was started, with the safety-valve wide open. When the fire was at its hottest, with a good mass of glowing coals and partly burned wood at bottom, the fire-box was filled with a compact firing of dry wood, and the safety-valve was closed. Time was noted at the instant of closing the fire-door and safety-valve,—pressure 0, by steam gauge, = atmosphere; and the time, to the nearest second, at which each 2·5 lbs. increase of pres-

sure was reached, was also observed and noted. As the number of thermal units to be imparted to the boiler and its contents—water and steam—to produce a given increase of pressure, grows less and less as the pressure rises, the line which represents the ascending pressure on the diagram, in which the abscissæ represent times and the ordinates pressures above the atmosphere, is a curve which could be calculated upon the assumption that the heating power of the fire was either constant or variable, according to some known law. The assumption adopted, that the heating value of the fire was sensibly constant during the period of time, 39·4 minutes, occupied in raising steam pressure from 0 to 140 lbs. above atmosphere, can hardly be exactly correct, but is probably quite near enough for the purposes of the experiment.

Without going into details which would hardly repay perusal, it is enough to say that taking into account the weight of the boiler and its attachments which are heated by the steam and hot water, and the specific heat of iron; the weight of water below the water line and its specific heat as modified by temperature; and the augmenting weight of steam in the steam-space and its diminishing ratio of increase of heat, all expressed in thermal units, the abscissæ for each increase of 10 lbs. in the pressure, as the same are computed, and observed, compare as follows:

Pressures by steam-gauge, pounds per square inch.	Abscissæ, time in minutes, computed.	Abscissæ, time in minutes, observed.
From 0 to 10	5·0	7·5
" 10 " 20	3·5	4·3
" 20 " 30	2·8	3·3
" 30 " 40	2·3	2·5
" 40 " 50	2·0	2·1
" 50 " 60	1·8	1·9
" 60 " 70	1·6	1·7
" 70 " 80	1·5	1·4
" 80 " 90	1·3	1·3
" 90 " 100	1·2	1·2
" 100 " 110	1 2	1·2
" 110 " 120	1·1	1·1
" 120 " 130	1·	1·
" 130 " 140	1·	1·
" 140 " 150	·9	·9

From this comparison it would appear that the fire gained in intensity during the first nineteen or twenty minutes, while the steam

pressure was going up to 50 lbs., and from that point remained sensibly constant, there being substantial agreement between the observed and computed times.

The steeply-rising full line at the left hand shows the resulting curve as observed; while the more steeply-rising dotted line near it, shows the same curve corrected for the simultaneous radiation.

When a pressure of 150 lbs. by steam gauge had been reached, the fire was rapidly withdrawn, removed to a little distance and quenched. A well fitted door of battened boards was placed under the fire-box hoop, and wedged up closely, and the smoke-pipe was removed and the outlet of the smoke-box closed. During these operations the steam pressure first rose and then fell a few pounds; but the rise and fall above 150 lbs., although noted, are omitted from the diagram, being affected by disturbing causes, such as the open doors, the draught of cold air through the flues, etc.

Cooling now being reduced to radiation from the outside of the boiler, including the steam jacket of the cylinder, the time occupied in falling from 150 lbs. to 50 lbs. was carefully noted for each 2·5 lbs. of pressure. The results, for intervals of 10 lbs. of pressure, are subjoined:

Pressures, pounds per sq. in.	Time, Minutes.	Pressures, pounds per sq. in.	Time, Minutes.
From 150 to 140	7·1	From 100 to 90	10·9
" 140 " 130	7·3	" 90 " 80	12·1
" 130 " 120	7·6	" 80 " 70	13·7
" 120 " 110	8·5	" 70 " 60	15·0
" 110 " 100	9·4	" 60 " 50	18·0

It is obvious that the time occupied in reducing the pressure by 10 lbs., at any point in the scale, is to the time occupied in raising the pressure the same amount at the same point, as radiation from the cooling surface is to absorption by the heating surface. The time of raising steam pressure, then, divided by the time of losing the same pressure by radiation, expresses the ratio of radiation to steam generation. Thus, between 50 and 60 lbs., 1·9 minutes sufficed to raise the pressure 10 lbs., while 18 minutes were required to reduce it as much. Therefore, $\frac{1{\cdot}9}{18} = {\cdot}106, = 10{\cdot}6$ per cent. = ratio of radiation to absorption at this point. These ratios will be found in the second column of table on the accompanying diagram.

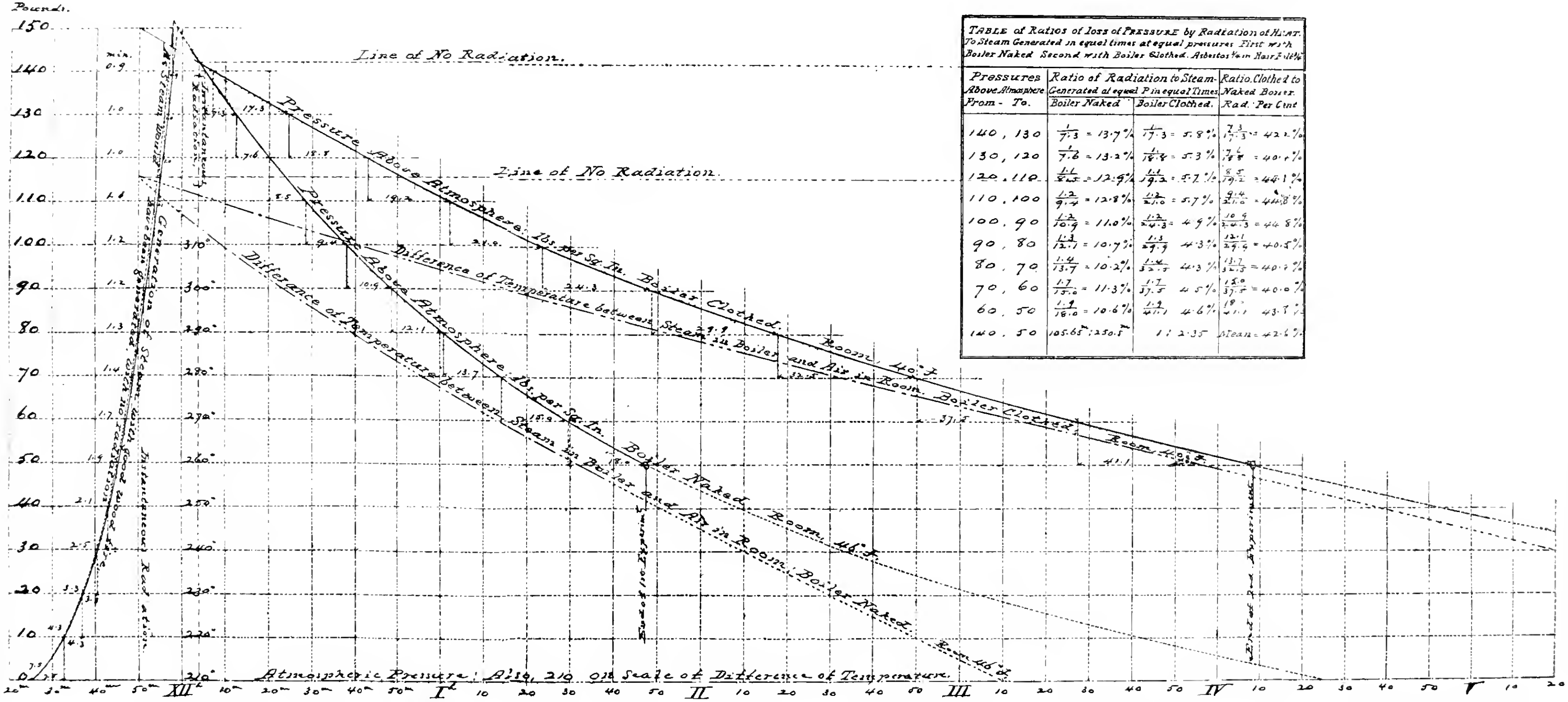

TABLE of Ratios of loss of PRESSURE by Radiation of HEAT. To Steam Generated in equal times at equal pressures First with Boiler Naked Second with Boiler Clothed. Asbestos ¼ in Hair Felt ¾			
Pressures Above Atmosphere From - To.	Ratio of Radiation to Steam-Generated at equal P in equal Times Boiler Naked	Boiler Clothed.	Ratio. Clothed to Naked Boiler. Rad. Per Cent
140, 130	$\frac{1}{7.3}$ = 13.7%	$\frac{1}{17.3}$ = 5.8%	$\frac{7.3}{17.3}$ = 42.2%
130, 120	$\frac{1}{7.6}$ = 13.2%	$\frac{1}{18.8}$ = 5.3%	$\frac{7.6}{18.8}$ = 40.4%
120, 110	$\frac{1.1}{8.5}$ = 12.9%	$\frac{1.1}{19.2}$ = 5.7%	$\frac{8.5}{19.2}$ = 44.1%
110, 100	$\frac{1.2}{9.4}$ = 12.8%	$\frac{1.2}{21.0}$ = 5.7%	$\frac{9.4}{21.0}$ = 44.8%
100, 90	$\frac{1.2}{10.9}$ = 11.0%	$\frac{1.2}{24.3}$ = 4.9%	$\frac{10.9}{24.3}$ = 44.8%
90, 80	$\frac{1.3}{12.1}$ = 10.7%	$\frac{1.3}{29.9}$ 4.3%	$\frac{12.1}{29.9}$ = 40.5%
80, 70	$\frac{1.4}{13.7}$ = 10.2%	$\frac{1.4}{32.5}$ 4.3%	$\frac{13.7}{32.5}$ = 40.7%
70, 60	$\frac{1.7}{15.0}$ = 11.3%	$\frac{1.7}{37.5}$ 4.5%	$\frac{15.0}{37.5}$ = 40.0%
60, 50	$\frac{1.9}{18.0}$ = 10.6%	$\frac{1.9}{41.1}$ 4.6%	$\frac{18.0}{41.1}$ 43.7%
140, 50	105.65^m : 250.5^m	1 : 2.35	Mean = 42.6%

Experiment to ascertain the effect of Boiler Clothing in retarding Radiation of Heat and Reduction of Pressure: Dec. 18. 1876; Jan. 12. 1877.
Portable Steam Engine No. 1274. 60 H.P., 12.5 in. cyl. 18 in. Str. Regulated to run light, at 182 Rev. per M.; loaded, at 175 Rev. per M.
Constructed by The J. C. Hoadley Company, Lawrence, Mass. — For William Sellers & Co., Philadelphia. Delivered on cars, Jan. 16. 1877. —

Experiments made calculations made and diagram designed and drawn, by J. C. Hoadley Jan 28. 1877.

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Table of Ratios of Loss of Pressure by Radiation of Heat to Steam Generated in Equal Times: First, with Boiler Naked: Second, with Boiler Clothed, Asbestos, ¾ in. Hair Felt, ¾ in. Galvanized Sheet-Iron Casing.

Pressures per sq. in. above atmosphere.	Ratios of Radiation to Steam Generation at Equal Pressures in Equal Times.		Ratio of Radiation from Clothed Boil. to that from Nak'd Boiler.
	Boiler Naked.	Boiler Clothed.	
From	Per Cent.	Per Cent.	Per Cent.
140 to 130	$\frac{1\cdot}{7\cdot3} = 13\cdot7$	$\frac{1\cdot}{17\cdot3} = 5\cdot8$	$\frac{7\cdot3}{17\cdot3} = 42\cdot2$
130 " 120	$\frac{1\cdot}{7\cdot6} = 13\cdot2$	$\frac{1\cdot}{18\cdot8} = 5\cdot3$	$\frac{7\cdot6}{18\cdot8} = 40\cdot4$
120 " 110	$\frac{1\cdot1}{8\cdot5} = 12\cdot9$	$\frac{1\cdot1}{19\cdot2} = 5\cdot7$	$\frac{8\cdot5}{19\cdot2} = 44\cdot3$
110 " 100	$\frac{1\cdot2}{9\cdot4} = 12\cdot8$	$\frac{1\cdot2}{21\cdot} = 5\cdot7$	$\frac{9\ 4}{21\cdot} = 44\cdot8$
100 " 90	$\frac{1\cdot2}{10\cdot9} = 11\cdot0$	$\frac{1\cdot2}{24\cdot3} = 4\cdot9$	$\frac{10\cdot9}{24\cdot3} = 44\cdot8$
90 " 80	$\frac{1\cdot3}{12\cdot1} = 10\cdot7$	$\frac{1\cdot3}{29\cdot9} = 4\cdot3$	$\frac{12\cdot1}{29\cdot9} = 40\cdot5$
80 " 70	$\frac{1\cdot4}{13\cdot7} = 10\cdot2$	$\frac{1\cdot4}{32\cdot5} = 4\cdot3$	$\frac{13\cdot7}{32\cdot5} = 42\cdot2$
70 " 60	$\frac{1\cdot7}{15\cdot0} = 11\cdot3$	$\frac{1\cdot7}{37\cdot5} = 4\cdot5$	$\frac{15\cdot}{37\cdot5} = 40\cdot0$
60 " 50	$\frac{1\cdot9}{18\cdot0} = 10\cdot6$	$\frac{1\cdot9}{41\cdot1} = 4\cdot6$	$\frac{18\cdot}{41\cdot1} = 43\cdot8$
140 " 50	$\overset{M}{105\cdot65} : \overset{M}{250\ 5}$ =	1 : 2·35 =	Mean, 42·6

There are some slight irregularities owing, probably, to the manner of conducting the experiments; but the several ratios are, on the whole, mutually confirmatory. At the more useful pressures, 80 or 90 lbs. to 120 or 130 lbs. above the atmosphere, the loss appears to be 11 to 13 per cent.

The corresponding curve of temperatures, shown below the curve of pressures, is obtained from the tables of the temperature of steam

at given pressures. For this purpose the scale of pressures is made to serve as a scale of degrees of temperature by adopting an arbitrary zero, such that 210° falls on the line of 0 pressure, the temperature of the engine room (46°) being deducted from that of the steam. The relation between the scale of pressures and that of temperatures, is purely arbitrary, and is adopted merely for convenience. The loss of heat is seen to be much more nearly in direct proportion to the time, than is the loss of pressure.

The boiler was afterwards clothed, first with three-quarters of an inch of asbestos cement, securely held in place by a sort of "lathing" of wire cloth of $\frac{1}{2}$ inch mesh, and over the asbestos a covering of hair felt, which when slightly compressed by the outer casing of galvanized sheet iron, was also about $\frac{3}{4}$ inch thick, making the whole covering about 1·5 inches. Around the smoke-box the entire thickness was of asbestos cement. This covering was complete over the fire-box casing including the door-end as well as around the barrel of the boiler, but did not extend over the steam jacket casing of the cylinder. There was also a space about 6 inches in height at the bottom of the fire-box, all around, which was left uncovered for convenience of access to hand-holes, mud-plugs and blow-off cock. This space, in setting, can mostly be covered with brickwork.

The process of raising steam was not again noted, as it was thought to be impracticable to make a second fire which should be known to be sufficiently like the first one, to admit of useful comparison: but loss of pressure by radiation was very carefully noted, the time being taken as each successive pound was reached, as well as each 2·5 lbs., the steam gauge being graduated to pounds. So much less heat escaped from the boiler that, although the day was rather warmer than at the first experiment, the engine-room (which had no other heat), was 6° Fahr. cooler than before: then 46°, now 40°.

The result of these observations is shown by the upper curve of the diagram; the corresponding fall of temperature by the curve, differing but little from a straight line, immediately below. The ratio of loss under these conditions to steam generated in the first experiment, is shown, for each interval of 10 lbs., from 140 lbs. down to 50 lbs., in the third column of table, and appears to be, for the same range of useful pressure before taken, 80 or 90 to 120 or 130 lbs. from 4 to 5 per cent., and the difference of ratios, which is the apparent saving effected by the clothing, about 7 per cent.

The times required by the naked boiler to reduce the pressure 10 lbs. at each stage, divided by the corresponding times required by clothed boiler, to effect the same reduction, show the ratio of loss by the clothed boiler to that by the naked boiler. For instance, between 50 lbs. and 60 lbs. the radiation from the naked boiler produced in 18 minutes an effect (10 lbs. fall of pressure), equal to that which the clothed boiler occupied 41·1 minutes in producing: therefore, $\frac{18}{41 \cdot 1} = \cdot 438 = 43 \cdot 8$ per cent., is the ratio at this point. These ratios will be found in the fourth column of the table. They are nearly constant, and their mean is 42·6 per cent. No correction is attempted for the 6° difference of temperature. Its effect is a slight understatement of the advantage of the boiler clothing.

What, then, is the economic value of such boiler clothing?

If the consumption of coal for 60 horse power is one ton per day of ten hours, say 300 tons per annum, a saving of 7 per cent. will be 21 tons per annum, amounting, at $6.00 per ton, to $126.00, rather over one-half the cost of the clothing. This, although less perhaps, than is commonly supposed, is an important saving. There are also obvious advantages in keeping up steam better during noontime. and whenever the engine is stopped. Perhaps a more efficient covering could be applied without making it too thick and cumbrous to be admissible on a portable engine boiler. The same total thickness here used, if entirely of felt, would be more efficient: but the felt would soon become charred. From this, the asbestos probably protects it. If ·7 or ·8 of the entire loss could be intercepted, the economy would be important. There is some incidental economy from the use of dryer steam, as all radiation from the iron around the steam space, leaves some water suspended in the steam or deposited on the inner surface of the boiler plates. The effect of having 7 per cent. less water to evaporate in a unit of time is also in the direction of economy. It is to be hoped that further contributions may be made to our knowledge of this important subject.

The table on the diagram is here reproduced for convenience of consultation. The dimensions of the boiler are also subjoined. The steam gauge used was one of the American Steam Gauge Company's 10″ standard gauges, which has never before been used exept to test other gauges by, and has been at three different times compared with a mercury column, with which it nearly agrees.

Dimensions of Boiler: Engine 12·5″ × 18″.

Diameter of barrel, inside, inches,		38
Thickness of iron in all outside sheets, inches,		$\frac{3}{8}$
“ steel in all inside sheets, inches,		$\frac{3}{8}$
Length of fire-box, inside, “		54
Width “ “ “		33
Height “ “ above bottom of hoop, inches,		47
“ “ “ “ top “ “		45·25
“ “ “ “ “ of grates, “		43
Size of doors (2 doors) in clear, inches,		10 × 16
“ “ outside of hoop, “		13·5 × 19·5
Number of screw stay-bolts in door end,		41
“ “ “ further end,		30
“ “ “ both sides,	81 × 2 =	162
Diameter of “ “ inches,		$\frac{7}{8}$
Width of water space, door end and sides, inches,		$1\frac{3}{4}$
“ “ “ further end, inches,		$2\frac{1}{2}$
Number of crown bolts,		60
Diameter of crown bolts, inches,		$\frac{7}{8}$
Number of double crown bars,		10
Length “ “ “ inches,		33·75
Dimensions of iron in crown bar, “		$4 \times \frac{1}{2}$
Arrangement of crown bars, 5 in. from c. to c. across fire-box.		
Longitudinal seams double-riveted.		
Number of flues, lap-welded iron,		63
Diameter of flues, outside, inches,		$2\frac{1}{4}$
“ “ inside, “		2
Length “ inches,		108
“ in clear between flue sheets, inches,		107
Heating surface, fire-box, total, square feet,		65·2
“ “ “ above hoop, square feet,		61·48
“ “ “ “ grates, “		58·76
“ “ flues, outside, “		330·90
“ “ “ inside, “		294·13
“ “ smoke-box, “		6·14
“ “ total, square feet,	65·20 330·90 6·14	402·24
“ “ above fire-grates and inside of flues,	58·76 294·13 6·14	359·93
Area of surface of water at 2·5 in. above top of crown sheet, sq. ft.		38
“ fire-grate, 4·5 × 2·75 square feet,		12·375
Ratio of heating surface, gross to area of fire-grate,	$\frac{402·24}{12·375} =$	32·5
“ “ “ net “ “	$\frac{359·03}{12·375} =$	25

ON THE LANCASHIRE BOILER, ITS CONSTRUCTION, EQUIPMENT, AND SETTING.

By Mr. Lavington E. Fletcher, of Manchester.

[Continued from Vol. ciii, page 206.]

The mudhole *A*, Figs. 1 and 2, at the front of the boiler, beneath the furnace-tubes, is also fitted with a substantial mouthpiece. This in some cases is external, like the manhole mouthpiece, and in others internal as shown in Fig. 1. The internal ones have the advantage of being less in the way. In either case the surfaces at the joint between the body of the mouthpiece and the cover are faced true, so that the parts may be brought together metal to metal.

The safety-valves *E*, and *F*, and the steam stop-valve *G*, are fixed to the shell, each with its own independent opening, and not grouped upon the manhole mouthpiece as is sometimes the case, the object of grouping them being to reduce the number of holes, on the principle that the fewer holes made in a boiler the better. This argument is plausible but fallacious. The manhole makes the largest opening, and therefore exerts the greatest weakening effect. The weakest link in a chain is the measure of the strength of the whole; so that fixing the steam stop-valve and safety-valves directly to a boiler with suitable fitting blocks does not weaken it. Moreover, for convenience in attaching the fittings, these group manhole mouthpieces are made of cast iron, which as already explained is objectionable. It is therefore recommended that manhole mouthpieces should not be complicated by the addition of the safety-valves or other fittings, but that each should be fixed direct to the shell and have its own independent attachment and thoroughfare.

Blocks for the Attachment of Fittings.—In old-fashioned practice the fittings were bolted directly to the cylindrical portion of the shell. This led to the wasting of the shell through leakage at the joints; so that it has long since been the practice to rivet short stand-pipes to the cylindrical portion of the shell and bolt the fittings thereto, the joint surface between the flanges being planed up true. These stand-pipes, frequently termed "fitting blocks," are not only more conve-

nient for the attachment of the fittings, but also, being riveted to the plate and made of substantial section, strengthen the plate round the hole cut in the shell. They are as a rule made of cast-iron, but it becomes a question whether, with the high pressures now in use, they should not be made of wrought iron. At one of the experimental bursting tests, a fitting block for a 6 in. steam valve-box was found to give way before any other part of the boiler, at a pressure of 275 lb. per square in., though the flange was $1\frac{3}{8}$ in. thick, the body $\frac{7}{8}$ in., and the metal sound.

Seams of Rivets.—Those running longitudinally in the cylindrical shell are all double-riveted, with $\frac{3}{4}$ in. rivets pitched about $2\frac{1}{2}$ in. longitudinally and 2 in. diagonally. The remaining seams throughout the boiler are single-riveted only, the rivets being 2 in. pitch. To double-rivet the transverse seams adds but little, if any, strength to the boiler, though it increases its weight and cost. It would appear that the strain upon the transverse seams of rivets in a Lancashire boiler is over-estimated. In a plain cylindrical boiler, without furnace-tubes, the strain on the transverse seams of rivets is precisely half that on the longitudinal seams. By the introduction of the furnace-tubes not only is the longitudinal strength increased, but at the same time the area of the ends upon which the steam acts is lessened, and thus the strain is lessened also; so that in the Lancashire boiler the strain on the transverse seams of rivets is less than half that on the longitudinal seams. The force of this reasoning however is sometimes disputed, and tie rods are introduced to support the transverse seams of rivets in the shell. But in the hydraulic bursting tests, with the tie rods removed, the longitudinal seams of rivets were found to fail in every case before the transverse seams, which never showed the slightest signs of distress and scarcely leaked a drop, while some of the longitudinal seams under severe pressure shortly before rupture leaked profusely.

The riveting is done by machine in preference to hand in the cylindrical shell, in the furnace-tubes, and as far as practicable in the flat ends. In the experimental bursting tests, the machine work in every case proved much tighter than the hand work. The rivet holes in the angle irons, T irons, and flanged seams are drilled, those in the plates being punched by most makers; though by some the holes are drilled throughout, and the practice of drilling is strongly advocated by them. In investigating an explosion that occurred at

Blackburn in March, 1874, the mean tensile strength in twelve tests of a solid plate was found to be 21·19 tons per sq. in., and in four tests of a punched plate 20·17 tons, showing a loss by punching of 1·02 tons per sq. in., or about 5 per cent. The question of drilling versus punching, and also of the pitch and diameter of rivets, is one that deserves further consideration; and it may be added that a boiler 7 ft. diameter, and made of plates $\frac{7}{16}$ in. thick, having the longitudinal seams double-riveted with $\frac{3}{4}$ in. rivets, pitched 3 in. longitudinally, instead of $2\frac{1}{2}$ in. as usual, was found tight at a hydraulic pressure of 120 lb. per sq. in. The edges of the plates at the longitudinal seams of rivets are planed and calked lightly, inside as well as out; though in many cases calking is superseded by fullering.

Material.—As a rule, boilers made under the inspection of the Manchester Steam Users' Association are of iron in the shell, while steel plates are very frequently introduced in the furnace-tubes for a length of 9 ft. over the fire, and sometimes from one end of the boiler to the other. For the furnace-tubes steel plates have been found to give great satisfaction, but a little suspicion has been entertained with regard to their use for shells, seeing that the plates are then in tension, and that a small flaw through brittleness might extend till it produced serious consequences. "Best best" plates fr[illegible] first-class makers are always recommended, more importance being attached to their ductility than to their tensile strength. Brands however are uncertain, and it is thought desirable that a complete system of testing should be adopted, and that, before a boiler is made, one plate out of the set proposed to be used should be tested as a check, the investigation having special reference to ductility. Low Moor rivets are frequently used and may be recommended.

Equipment.

Arrangement of Fittings.—The fittings are so arranged that all those requiring frequent access are immediately within reach of the attendant when standing in front of the boiler. The feed is introduced on one side of the front end plate, about 4 in. above the level of the furnace crowns, an internal dispersing pipe *H*, Figs. 1 and 3, being carried along inside the boiler for a length of about 12 ft., and perforated for the last 4 ft. of its length. On the opposite side of the front end plate is fixed the scum tap, to which is connected a series of sediment-catching troughs *K*, Fig. 3, fixed inside the boiler.

In the centre of the end plate are two glass water-gauges *J J*, Fig. 2, so that one may act as a check upon the other, a pointer being fixed to show the correct height at which the water should be kept. Immediately above the water-gauges is a dial pressure-gauge *L*, and above that a dead-weight safety-valve *E*. Thus whenever the attendant opens the furnace doors to charge the fires, he has the height of the water and the pressure of the steam directly before him. Under his feet is the blow-out tap, and behind him the coal supply, so that everything is ready to hand. He has not to climb a ladder in order to reach the water-gauges or ascertain the steam pressure, nor to mount on the top of the boiler in order to regulate the feed supply. A handle for regulating the dampers is frequently brought to the boiler front. On the top of the boiler are two safety-valves, one a dead-weight valve *E*, of external pendulous construction, the other a low-water valve *F*, Fig. 1.

But convenience in manipulation is not the only reason for this arrangement of fittings. If the feed be cold and be introduced near the bottom of the boiler, it is apt to induce local contraction, and thereby strain the transverse seams of rivets at the bottom of the shell; but when introduced near the surface of the water and passed through an internal perforated pipe, it becomes dispersed before falling to the bottom. Further, although non-return valves may be introduced, they will sometimes fail and allow the water to escape, whereby the furnace crowns become bare and overheated. When the feed inlet is placed above the level of the furnace crowns, it will be seen that they cannot be drained bare by leakage at the non-return valve; but when placed at the bottom of the boiler, the boiler may then be emptied by such an occurrence.

Safety-Valves.—The dead-weight valve, which is of the Cowburn type, as shown in Fig. 10, Plate V, is extremely simple and efficient. The centre of gravity of the load being below the seating renders unnecessary either wing or fang for keeping the valve in position, and it has therefore no frictional surface to get tight or stick fast. These valves are loaded with flat annular plates or rings, and the shell is cast with mouldings around it at the bottom which present the same appearance, the whole being so adjusted that each moulding as well as each annular plate represents a pressure of 5 lb. per sq. in. on the valve. Large numbers of these valves are in use, and they are highly approved. The diameter generally adopted is 4 in., which requires

approximately a load of 8 cwt. for a blowing-off pressure of 75 lbs., and 11 cwt. for 100 lb. per sq. in. On this valve the addition of two or three bricks produces no appreciable effect, whereas at the end of a long lever the result would be different. To double the blowing off pressure it would be necessary to add about 8 cwt. to the load for 75 lb., and 11 cwt. for 100 lb. Such an addition there would be great difficulty in attaching to the valve, and if it were done it would be so conspicuous as at once to call attention to the fact. The great weight required to load this valve is considered therefore to be a safeguard: and several explosions due to overloading have been met with, which would have been prevented by its use.

The low-water safety-valve shown at *F*, in Fig. 1, is of the Hopkinson type: but there are also the Kay and the Lloyd low-water valves, which though varying in detail are similar in their object. Each has a lever inside the boiler, to which is attached a float, so that when the water falls below the desired level the float falls also, and thus raises the valve and allows the steam to blow off, thereby not only giving an alarm but also lowering the pressure. Hopkinson's valve is a compound one, having one valve seated on another; the central portion is loaded by a dead weight inside the boiler, and operated upon by the lever in the event of low water, while the annular portion is loaded by an external lever and weight, and lifts along with the central portion in the event of high steam; these valves therefore blow off on the occurrence either of high steam or of low water. The outer valve is 5 in. diameter, and the inner one $2\frac{1}{2}$ in. The freedom of the steam valve can be tested by placing the hand on the lever when steam is up; while the freedom of the low-water apparatus can be tested by opening the blow-out tap and lowering the water-level to within about 6 in. of the furnace crowns. To overload this valve without increasing the weight outside would necessitate getting inside the boiler and wedging down the dead weight. Under such circumstances the application of the hand to the external lever when steam was up would at once show that something was wrong; and even if this were not detected the external dead-weight valve at the front of the boiler, if free, would come to the rescue, while, if overloaded, this would be apparent at a glance. It is sometimes recommended to have safety-valves under lock and key, but it is preferred by the writer to have them thoroughly open, so that their publicity may be their protection. While it is fully admitted that no arrangement of safety-

valves can be contrived which cannot be tampered with by skilled malice, it is thought that the combination of the two valves just described and shown in Fig. 1, forms a very safe arrangement.

Furnace Mountings.—The furnace mouthpieces *N N*, Fig. 2, are of wrought iron, finished off with a neat brass beading, and kept within the circle of the rivets, so as to leave these exposed to view. The fire-doors are fitted with a sliding ventilating grid on the outside and a perforated box baffle-plate on the inside, the aggregate area of the air passages being about 50 sq. in. for each door, or about 3 sq. in. per sq. ft. of firegrate. The firegrate is 6 ft. long, with the bars in three equal lengths, about $\frac{3}{4}$ in. thick, and spaced $\frac{3}{8}$ in. apart for windage. The bearers consist of two wrought iron bars carried on wrought-iron brackets riveted to the sides of the furnace-tubes. The standard length of grate is 6 ft., but a shorter one is productive of economy, though the concentration of the fire is more trying to the boiler, and has been found, where the feed water has not been good, to injure the furnace plates, and render lengthening the grate necessary.

Setting.

External Brickwork, Flues, and Course of Draught.—The boiler is set on side walls, and rests on firebrick seating blocks presenting a bearing surface 5 in. wide, as shown in Fig. 3, Plate III. The side flues are 6 in. wide at the top, carried up to the level of the furnace crowns or a few inches above, and down to the level of the bottom of the shell. The bottom flue has a width equal to the radius of the boiler, and a depth of about 2 ft These dimensions admit of ample room for inspection. By keeping the width of the bottom flue equal to the radius of the boiler, the angle that the bearing surface of the seating block makes with the horizon is 30° for any diameter of shell.

The flame immediately after leaving the furnace-tubes passes under the bottom of the boiler, and returns to the chimney along the side flues. This is not the course approved by Mr. Pole in his treatise on the Cornish Pumping Engine, published in "Tredgold on the Steam Engine" in 1844, in which the setting of the Cornish boiler is spoken of as follows:—"The heated current first impinges on the top of the tube, over which the highest and therefore the hottest portion of the water is lying; it then passes along the side flues, where it finds the

surfaces cooler than before; and last of all it traverses under the bottom of the boiler, where the coldest water will always be. By this means the fire current, as it gradually cools, is likewise gradually brought to act upon cooler water, and thereby the best opportunity is afforded for the extraction of the free caloric it contains. . . . . The descending motion of the fire current, as it cools in the flues of the Cornish boiler. is upon statical principles much more natural and calculated to prevent the unnecessary discharge of heat into the chimney than the ascending principle of the ordinary boilers." Allowing the last heat however to travel under the bottom of the shell does not promote the circulation of the water, or at all events but slowly; so that in getting up steam the top of the boiler becomes hotter than the bottom, from which straining ensues. If in addition to this, the feed water when cold be pumped in at or near the bottom of the boiler, the straining at the transverse seams of rivets is intensified. Possibly the Lancashire boiler is more subject to straining and seam-rending at the bottom of the shell than the Cornish, as there is a greater body of dead water lying there in the Lancashire boiler, in addition to which the rate of combustion per sq. ft. of fire-grate is much more rapid in the Lancashire district than that generally adopted in Cornwall. In consequence of seam rents occurring at the bottom of Lancashire boilers when the last heat is carried underneath, the plan of passing the flame under the bottom immediately on leaving the furnace tubes, and also of introducing the feed water near the surface, has become the general practice. The question of economy is met by the use of feed-water heaters, consisting of a number of water pipes placed in the main flue between the boiler and the chimney. and kept free from soot by an automatic scraper. A good feed heater will raise the temperature of the water to about 240°. This answers two good purposes: it economizes the waste heat escaping to the chimney and thus reduces the coal consumption. while at the same time it prevents local cooling, thereby preventing straining and saving repairs. It has been found by experiment that passing the flames from the furnace tubes around the outer shell. instead of direct to the chimney, adds but little to the yield of steam, though it promotes economy of fuel: at the same time it keeps the boiler at a more equable temperature throughout.

The flooring or hearth plates at the front of the boiler are set so as not to butt against the boiler, which is too often the case, but so as

to be entirely below it, as in Fig. 2, thus leaving the whole of the front end plate open to view. Where there is a range of boilers, these flooring plates extend throughout the width of the boiler house; and being finished off with a fender-flange where abutting against the boundary walls of the building, as well as against the face of the brickwork setting, they present a very neat appearance. These plates are carried on a complete system of framing, and are arranged for easy lifting. The hearth pit beneath them is open from one side of the boiler house to the other, and in this is laid the main feed-pipe, as well as the discharge pipe from the blow-out and scum. This pit is about 3 ft. wide by $2\frac{1}{2}$ ft. deep, so as to afford room for access: the flue doors open into it. The face of the brickwork at the front of the boilers is set back 6 in., so as to leave the angle-iron with its circle of rivets perfectly open. The front cross wall beneath the boiler is recessed around the blow-out elbow-pipe, so that it may be free to move should settlement of the boiler take place.

Boiler Covering.—The boiler is covered with an arch of brickwork, leaving a space of about 2 in. between it and the plates, as in Fig. 3; and a layer of cork shavings or a coating of good boiler-composition or other suitable non-conducting substance is introduced into this space. Openings finished off with bull-nosed bricks are worked round the fittings, so as to leave the ring of rivets by which they are attached to the shell exposed to view. Sometimes the boiler is covered simply with a layer of composition, which should not be carried over the flanges of the fittings, as is too often the case, but should be stopped off by means of curb hoops dropped around the flanges, and a curb cast-iron nosing to guard the front angle-iron.

Connections.—All connections to boilers should be elastic, so as to allow of their movement. If the main steam-pipe be carried across the boilers and bolted direct to the steam junction valve, the joints are strained by the rising and falling of the boilers as they are set to work or laid off. To prevent this, a springing length should be introduced between the steam-stop valve *G*, and the main steam-pipe, as shown in Fig. 1. Where the main steam-pipe has a considerable length to travel to the engine, it should not be taken in a direct line, but should either be carried round the boiler house or be led in a horse-shoe shaped course, to give elasticity; this is better than introducing an expansion joint, which is not reliable. Sometimes expan-

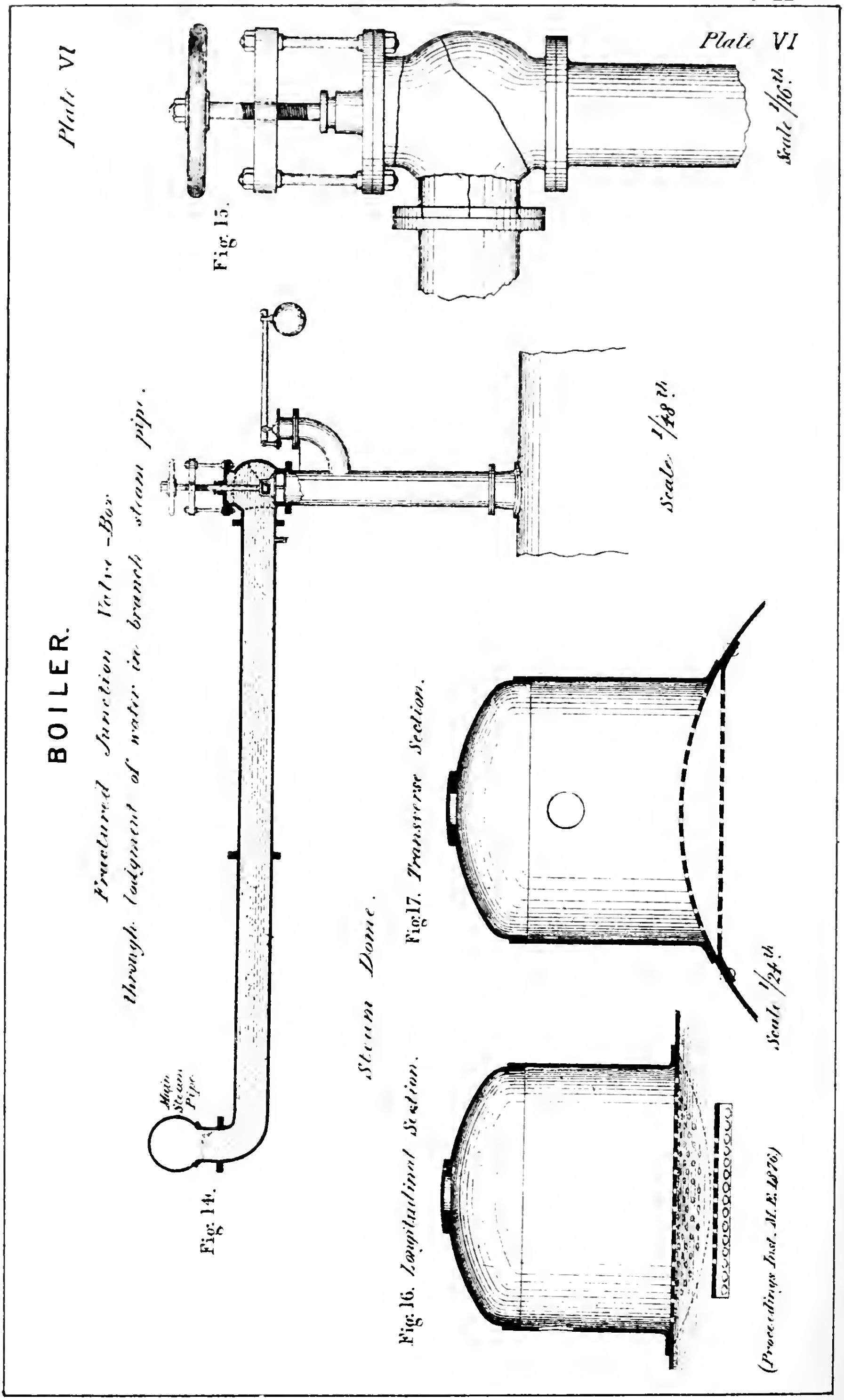


Plate VI
Plate VI
BOILER.
Fractured Junction Valve-Box
through lodgment of water in branch steam pipe.
Fig. 14.
Main Steam Pipe
Scale 1/48th.
Fig. 15.
Scale 1/16th.
Steam Dome.
Fig. 16. Longitudinal Section.
Fig. 17. Transverse Section.
Scale 1/24th.
(Proceedings Inst. M.E. 1876.)

sion diaphragms are adopted; but these when as much as 4 ft. diameter have been known to lead to the fractures they were intended to prevent, the internal pressure causing them to bulge outwards, when it was expected that they would allow the pipes to expand and thrust them inwards. A case of this sort has recently come under the writer's knowledge, in which the main junction valve was broken off by the thrust occasioned by the bulging of the expansion diaphragm. It is equally important that the feed connection should be elastic; and from the want of elasticity, feed valve-boxes have been known to fracture. For this purpose a copper elbow connecting-pipe *P*, Figs. 1 and 2, is introduced between the main feed-pipe and the stand-pipe; in some cases a wrought iron horse-shoe shaped pipe has been adopted instead, with very satisfactory results.

Connections between the steam stop-valve and main steam-pipe are frequently made to incline upwards, as in Fig. 14, Plate IV, so that the water may drain back to the boilers. This plan however is objectionable; for when one of the boilers in a range is laid off, the connecting length becomes filled with water from condensation of the steam, which, cooling by radiation, sets up a violent conflict with the steam, whereby the pipes are sometimes fractured. The action may be illustrated by the commotion which occurs within a locomotive tender when the steam from the boiler is turned into it. Further than this, on opening the steam stop-valve of a boiler that has been laid off, the water lying on the top of the valve, as in Fig. 14, is apt to be carried forward by the rush of steam, like a water hammer and sometimes to burst the pipes. To prevent this the steam-pipe should drain towards the engine, and not towards the boiler, its course being intercepted by a separator fixed as near the engine as convenient. The principle on which these separators act is that of making the steam take a sharp turn, so as to shoot off the water mixed with it into a catch-chamber prepared for the purpose. Many of these separators are now at work; the principle was advocated by Dr. Haycraft of Greenwich, twenty-five years ago.

Additional Particulars.

Weight and Cost.—The weight of such a boiler as has now been described, when 7 ft. diameter, 27 ft. long, and made of plates $\frac{7}{16}$ in. thick, is about 12 tons without fittings; with fittings $15\frac{1}{2}$ tons. The cost at the present time, delivered on the premises of the purchaser

within a few miles of Manchester, and including the attachment of the fittings, is about £425. The plan of buying a boiler at so much per ton, and then the fittings at so much extra, is quite given up in favor of purchasing the whole for one sum.

Heating Surface.—Such a boiler has a heating surface in the external shell of 370 sq. ft.; in the furnace-tubes, without water-pipes, 450 sq. ft.; in the water pipes 30 sq. ft.: making a total of 850 sq. ft. The fire-grate has an area of 33 sq. ft.; this gives for every square foot of fire-grate 26 sq. ft. of heating surface.

In feed-water heaters the surface varies; sixty pipes, each affording a heating surface of about 10 sq. ft., are now frequently introduced per boiler, making a total heating surface of 600 sq. ft., or about three-fourths of that in the boiler.

Working Results.—From 15 to 20 tons of coal in a week of 60 working hours, or from 17 lb. to 23 lb. per sq. ft. of fire-grate per hour may be burnt in such a boiler without distressing it. This may be done without making smoke; all that is needed is to maintain a good thickness of fire, throw on the coal little and often, admit a little air above the bars for a short time after firing, and avoid the use of the rake. The coal may either be spread over the whole surface of the fire or thrown at alternate firings first to one side of the furnace and then to the other, on the "side firing" system introduced by Mr. C. Wye Williams.

A Lancashire boiler experimented on at Wigan, with furnaces 2 ft. 7½ in. diameter and a fire-grate 4 ft. long, evaporated 83·54 cub. ft. of water per hour, from a temperature of 100° Fahr., at the rate of 10·44 lb. of water per lb. of coal, when burning 24 lb. of coal per sq. ft. of fire-grate per hour. With a fire-grate 6 ft. long it evaporated per hour 98·58 cub. ft. of water at the rate of 10·37 lb. of water per lb. of coal, and burnt 19 lb. of coal per sq. ft. of fire-grate per hour. These results were obtained at atmospheric pressure, with the help of a water heater, with good round coal and without making smoke. The boiler described in this paper, having furnaces 2 ft. 9 in. diameter, would evaporate a larger quantity of water per hour. Such a boiler is found in practice to be capable, provided the steam be applied to a fairly economical engine, of developing 200 Ind. h. p., and 20 Ind. h. p. per lineal foot of boiler frontage, side flues included. A Cornish boiler under similar conditions is capable of developing

16 Ind. h. p. per lineal foot of boiler frontage. This leads up to the important question of the utilization of the steam, which the late Mr. Robert Stephenson defined as its "administration," and fuller information is yet needed as to the comparative advantage of working steam on the compound or single-cylinder principle; also as to the value of steam-jackets, as well as with regard to the initial and terminal pressures most conducive to economy. These inquiries, though full of interest, cannot be entered upon in the present paper; but one of the essentials to economy is the power of raising high-pressure steam steadily and safely, and this may be accomplished by the use of the Lancashire boiler.

At least 300 or 400 boilers have been made, of similar construction and equipment to that described in this paper; and among others it may be mentioned that a series of four such boilers can be seen at the Houses of Parliament, employed for heating and ventilating, which were laid down in the year 1869 by Mr. Joseph Clayton of Preston, who was one of the first to assist in carrying out the views of the writer in getting up a first-class boiler equipment for the service of the members of the Manchester Steam Users' Association.

Improvement in Ceramic Manufacture.—M. Faure, a mechanic of Limoges, has invented an attachment to a turning lathe, enabling him to accomplish by machinery the final operation of plate moulding, which has hitherto been done by hand. The appliance gives great uniformity to the work and a large increase of production, turning out an average of fifty pieces per hour. This completes the series of M. Faure's inventions for the manufacture of plates by machinery.—*Soc. d'Encouragement pour l'Industrie nationale*, Dec. 22, 1876; *Les Mondes*, Feb. 15, 1877. C.

Utilizing Solar Heat.—M. Mouchot, by means of conical mirrors, boils coffee, cooks meat, and obtains thermo-electric currents of great energy, from the sun's rays. An opening of four metres square yields a motive force of one-fourth of a horse power. M. Mangon thinks that in Algeria, in the south of France, and in Spain, where there are more than 200 days of utilizable sun-force, the power can be used with as much advantage as the Hollanders and other northern people derive from the wind by means of their windmills.—*Ibid.* C.

ON THE BEST ARRANGEMENT OF CITY STREETS.

[Contribution from the Department of Civil Engineering, Towne Scientific School, University of Penna.]

By Prof. Lewis M. Haupt.

It may be safely assumed *that facility of communication is one of the most potent elements of human progression and development*, hence any obstacle to mobility, however small, becomes a bar to progress, and should, if possible, be removed.

It becomes immediately evident therefore, that the rectangular system of streets is, by itself, defective in consequence of the angles which it opposes to diagonal communications.

Great merit has been awarded Wm. Penn for his prescience in planning this city of Philadelphia, but whilst that plan might answer admirably the requirements of a village, it is very inappropriate to a city of this magnitude. As a matter of history, Penn's letter of instructions to his three commissioners, appointed to execute his designs, will be read with interest.

They were "to seek out a spot on the Delaware River where it is most navigable, high, dry and healthy, where ships may best unload without litering, and where there is good soyle for provisions.

"Having found such a place, lay out ten thousand acres contiguous to it in the best manner you can, as the bounds of said towne; that no more land be laid out until this is taken up; which is the best both for comfort, safety and traffic.

"Be sure to settle the figure of the towne so as the streets may be uniform down to the river.

"Let the place for the store house be on the middle of the key, which will yet serve for market and state house too, only let the house built be as much upon a line as may be.

"The distance of each house from the creek or harbor should be in my judgement a measured quarter of a mile, at least two hundred paces, because of building hereafter streets downward to the harbor.

"Let every house be placed, if the person pleases, in the middle of its platt, as to the breadth way of it so that there may be ground on each side for gardens, orchards or fields, that it may be a greene country towne which will never be burnt, and always be wholesome.

"Given at London, Sept. 15, 1681."

Such was the inception of this, the largest city in area, of the western world. Its growth has far surpassed the most sanguine expectations of its founders, because it combines in its site so many natural advantages. It is readily reached by land or water, its topography is sufficiently undulating to furnish a most perfect system of drainage, with cheap and good water supply, and it has in general a firm and dry soil. Had the original idea of disconnected buildings been adhered to, however, it would always have remained a "greene country towne" of such magnificent distances that but few people could have afforded to live in it. Where would our present population extend to if so domiciled? As concentration and proximity were found to be important elements of defense, intercourse and social and intellectual development, the colonizers soon abandoned the plan and congregated along the river front in both directions until communication became inconvenient, when they began moving along High (now Market) Street towards the Schuylkill.

The rectangular arrangement of streets as proposed being found objectionable, it becomes necessary to examine what other systems, if any, may be used, and determine their relative merits. They may be 1st, *regular*, or 2d, *irregular*, and the first class may be subdivided into rectangular, diagonal and circular; the second into every possible kind of distortion more or less intricate, according to the circumstances attending the growth of a city. All the latter class are discarded as being unscientific, expensive, inconvenient and poorly adapted to the requirements of a growing community.

As people move through a city in every conceivable direction it will be impossible to provide the shortest lines for all, but the case may be met by supposing a greater or less number of centres or *points d'appui*, to and from which the currents of daily life flow and ebb.

With reference to the subdivisions of the first class it is evident that the straight line being the shortest distance between two points the chord will be shorter than its arc and hence the circular system is defective. The rectangular compels a waste of distance and time and the diagonal by itself becomes the rectangular, so that no single system fulfils all possible requirements. A combination must therefore be resorted to, and that composed of right line elements is both the simplest and most direct. A judicious arrangement of diagonal streets with the rectangular system will doubtless be found to meet more fully than any other, the requirements of the case, but it is

evident that if the streets be too wide or too numerous the building areas will be correspondingly decreased and a certain proportion of people forced beyond given limits, thus increasing their distances. On the other hand the diagonals will in general open new building lines, with more than residences enough to provide for all the displaced inhabitants.

To illustrate the utility of such a combination, suppose a portion of a town or city to be laid out in the form of a square whose side is L feet long, and in which the *blocks* are l feet square and the streets w feet wide.

Let the diagonals of the large square be opened as thoroughfares, and note their effect. The *blocks* or small squares extend from the middle of one street to that of its parallel, or from the building line of one block to that of the next, hence the length of a side of such square must be $l + w$ (Fig. 1). The area of the small square, including the streets, multiplied by the number of such squares will give the area L^2 of that portion of the city, and the ratio of street to property area is the same for the small as for the large squares, but the area of the small squares is $(l + w)^2 = l^2 + 2\,lw + w^2$ in which l^2 is the property or building area and $2\,lw + w^2$ is the street area; the ratio being $\frac{2\,l\,w + w^2}{l^2}$ and *the percentage of street to property area,*

$$\left(\frac{2\,l\,w + w^2}{l^2}\right) 100 \quad . \quad . \quad . \quad . \qquad \text{(A)}$$

For *any* rectangle with streets, of unequal widths, the general formula would be:

$$\frac{b\,c + a\,d + b\,d}{a\,c}\,100 \quad . \quad . \quad . \quad . \qquad (\text{A}^1)$$

in which a and c are the sides of the rectangle, and b and d the widths of the streets. If these quantities are equal, each to each, A^1 becomes A. The number (n^2) of blocks in a given square, whose area is L^2, will be:

$$\frac{L^2}{(l + w)^2} = n^2 \quad . \quad . \quad . \quad . \quad . \qquad \text{(B)}$$

If now two diagonals, $\overline{M\,N}$ and $\overline{PQ}$, be introduced, it is evident that where they cross the rectangular streets no additional area is taken from the private property of the city, but they will cut out of

Fig. 2

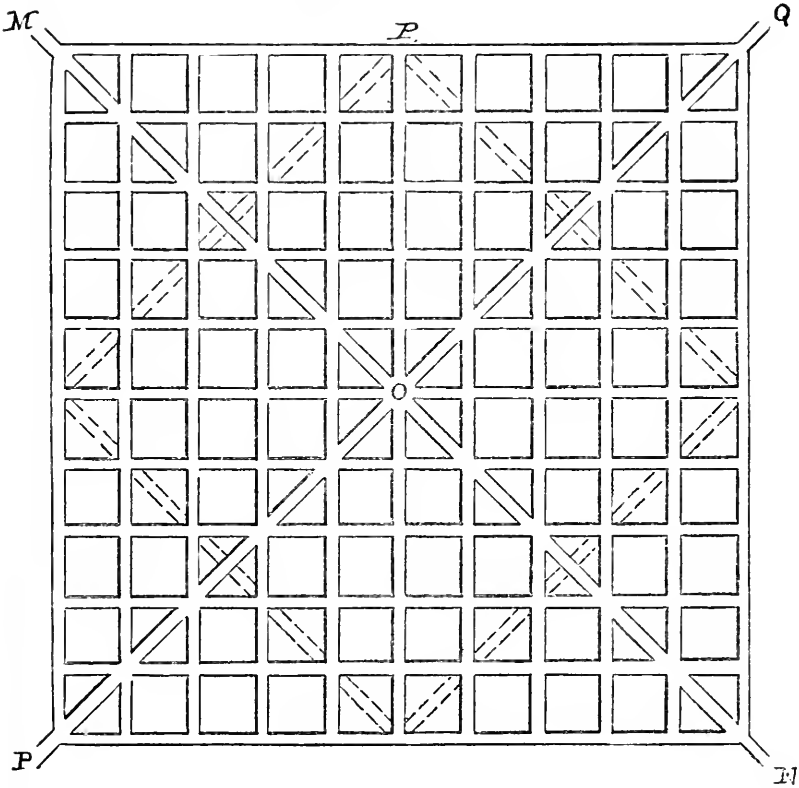


Fig. 1

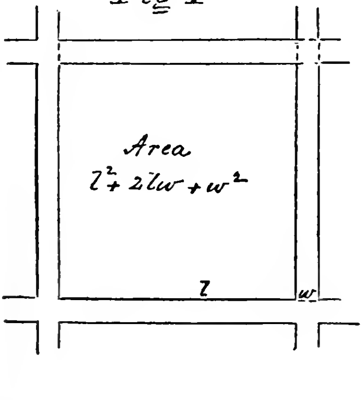
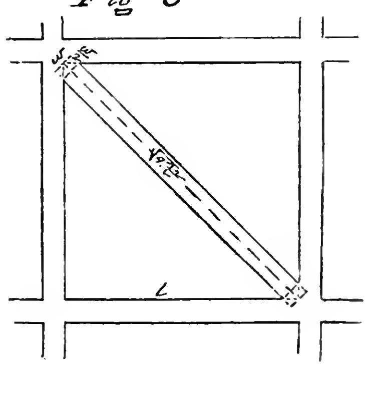


Fig. 3



each of the small squares which they cross an area whose length is $\sqrt{2 l^2} - \frac{w}{2}$, breadth w, and whose area for one block, l^2, is $\left(\sqrt{2 l^2} - \frac{w}{2}\right) w$ (see Fig. 3). For n blocks the total building area consumed from L^2 by both diagonals, when n is even, will be $2 n w \left(\sqrt{2 l^2} - \frac{w}{2}\right)$, and the percentage of the building area will be $\frac{2 n w}{n^2 l^2} \left(\sqrt{2 l^2} - \frac{w}{2}\right) \times 100$, which reduces to

$$\frac{w}{n l^2} (2{\cdot}828\, l - w)\, 100 \quad . \quad . \quad . \quad . \qquad \text{(C)}$$

the formula for diagonals when n is even. If *n be odd, C* becomes:

$$\frac{w}{n l^2} (2{\cdot}828\, l)\, 100 = 282{\cdot}8426 \frac{w}{n l} \quad . \quad . \qquad \text{(C}^1\text{)}$$

If diagonals be opened, benefits will accrue both from the shortening of distance and the additional frontage which will be furnished, while but a small proportion of the inhabitants will be displaced. The greatest economy in distance will be in passing from M to O (Fig. 3), which by the square system is equal to L, and by the diagonal $L \sqrt{\frac{1}{2}}$, the ratio being $\frac{L \sqrt{\frac{1}{2}}}{L} = \frac{1{\cdot}4142}{2} = \frac{70}{100}$, the numerator indicating the distance (in feet) by the diagonals, the denominator by the squares. This gives a gain of 30 per cent., which is the greatest amount possible, and from which it diminishes to zero at P.

The total length of *frontage* on the streets in the square system is $4 l n^2$. The diagonals give an additional length of $4 n (\sqrt{2 l^2} - w)$, and the percentage of increase is, therefore:

$$\frac{l \sqrt{2} - w}{l n} 100 \quad . \quad . \quad . \quad . \quad . \qquad \text{(D)}$$

The ratio of people displaced is the same as that of the area consumed by diagonals to the entire area L^2.

To determine these values for any particular case, and so discover whether or not the diagonals will be beneficial, let $l = 500$ ft., $w = 50$ ft., and $n = 10$.

Formula (A) gives 21 as the percentage of *large or small* squares consumed by streets in the rectangular system.

Formula (C) gives only 2·82 per cent. of additional building area consumed by diagonals.

Formula (D) gives 13 per cent. as the increase in frontage due to diagonals, and it has been shown that the saving of distance varies from 30 per cent. to nothing.

The number of people displaced, which is but 2·82 per cent., will be abundantly provided for by the additional frontage on the diagonals, revenues will be augmented by assessments on the new buildings erected, and a large saving will be effected in time and distance for a majority of the inhabitants by this combination of systems, which is therefore found to fulfil the requirements of practice more fully than any other.

Similar applications of the above formulæ will show to what extent the plans of cities already established or to be built, may be improved by the opening of diagonals, the most economical relation of street to building area, the proper distribution of the street area, and, by extending the analysis, the ratio of pavement to carriage way may also be readily determined. All of these questions have a direct bearing on the convenience, health, and extension of our cities.

St. Gothard Railway.—The estimated cost of this enterprise when it was first undertaken, was 187,000,000 fr. It has been found, however, that grave mistakes were made in the original calculations, and M. Hellwag, the present chief engineer, states in his report to the Swiss Government, that an additional capital of at least 102,000,000 fr. will be required in order to finish the work. The original estimates were based upon maps on a scale of 1 : 10,000, and did not make sufficient allowance for the protection which would be required against mountain torrents, avalanches, land-slides, falling rocks, and other like contingencies. In consequence of this serious miscalculation the works are suspended, except in the grand tunnel, which has been driven to more than half its length. The decision as to future action is complicated by political questions, arising from the subventions of the German and Italian governments; but the Swiss federal council has appointed a commission of engineers to report upon M. Hellwag's propositions, and it is hoped that satisfactory measures will be devised for carrying them out.—*Annales des Ponts et Chaussées*, Jan., 1877. C.

CERTAIN POINTS IN THE DEVELOPMENT AND PRACTICE OF MODERN AMERICAN LOCOMOTIVE ENGINEERING.

By Francis E. Galloupe, S. B.

[Continued from Vol. ciii, page 173.]

It should be said that hardly any of the data will be found to be exact. For, first, since they were wholly taken by one person, where several things had to be observed at once, such as the time, the speed, and the steam pressure, a difference in the time of taking the three, with the accompanying changing conditions, was necessarily perceptible; and, second, no more exact methods of taking the data, such as the use of appliances for making a test, scales, measuring tanks, speed recorders and dynamometers, the use of all of which, with the addition of indicator diagrams taken from the cylinders, would of course be preferable and which it would have given me great pleasure to have attempted, could be employed, on account of the interference they would have caused with the duties of the engineer in the running of the engine. The memoranda are therefore observations only, which could be made in the cab, and do not represent experiments, and it is only from the lack of such data from American engines that I cause them to occupy so prominent a place in my discussion by inserting the records in full.

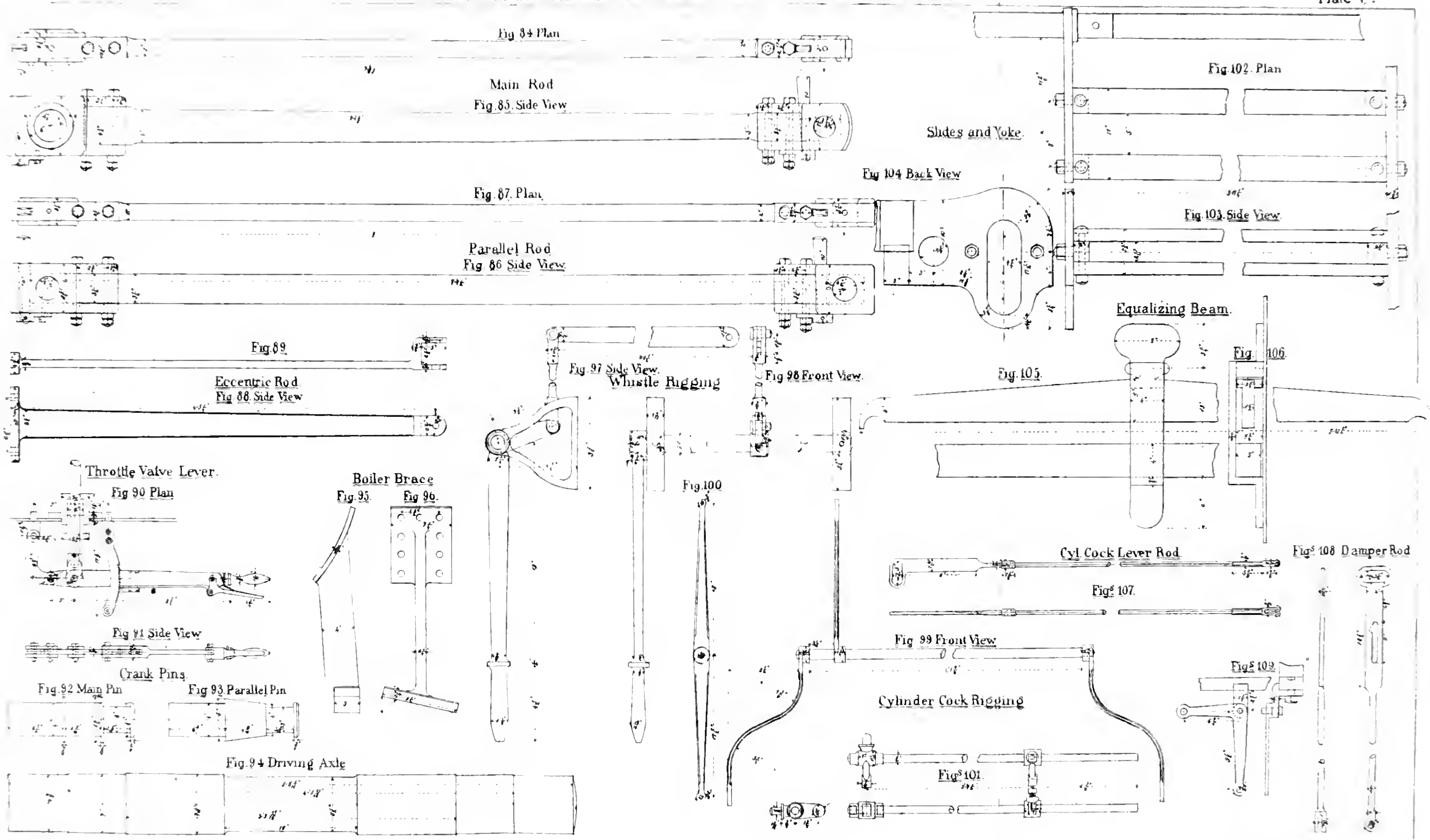
Precisely what the columns of these tables represent will now be stated.

Column 1. *Miles to or from Boston.*—These distances were obtained from the published time table of the Eastern Road. Considering that these were not strictly accurate, application was made to the chief engineer of the road for a profile map by which the distances could be obtained with greater accuracy, and also the grades at any points of the road at which the speed was taken. Being disappointed in this, for the reason that no regular survey of the road has been made since its construction, I was obliged to take the time table distances as a basis, and remedy the inaccuracies, as well as I could, from personal knowledge of the road.

Columns 2 and 3 require no explanation, further than to say that where the times are given, in column 2, a stop was made, and there

DETAILS OF PASSENGER ENGINE BY HINKLEY LOCOMOTIVE WORKS.

Plate C.



Weissenborn's "American Locomotive Engineering"

Francis E Galloupe

were no others except where indicated in column 5, which shows the number made on each trip.

Column 4. *Train Arrivals and Departures; Corrected Time by Watch.*—These were noted by the second hand of the watch at the instant of full stop and starting. Where two times are given opposite the name of one station, the upper one signifies the stop, the lower one the start, and opposite in column 6, are the steam pressures at those instants.

Although the watch used had been just previously regulated, the jar of the engine influenced its rate, and I have thought it well to apply a correction to the times in order to insure greater accuracy in the results involving their use, in the other columns. This was done by the following method.

From Tables I and II, on Wednesday, March 15, it will be seen that it was noted at Boston before leaving that the watch had been set by the depot clock, which gives correct Cambridge time, so as practically to agree with it at 8.30 A. M., and it is also noted that on the return to Boston the watch was 15 seconds fast by the clock at 1.55 P. M. Let the horizontal line, $A\,B$, represent this duration of time, in the accompanying diagram. The length of this line represents the interval (12 M. — 8.30) + 1.55 = 5 hours, 25 minutes. At the end of this interval the watch was 15 seconds fast, and this is represented by the ordinate or positive distance, $B\,C$, above the line $A\,B$. Now at the beginning, or at 8.30 A. M. the watch coincided with the clock; hence by drawing the diagonal line $A\,C$, we represent the gain of the watch by the length of the ordinate at any point, *on the assumption that the rate was the same, or that this gain was uniform*, during the whole interval. To obtain the true time, we must therefore subtract from the indication of the watch at any time, a number of seconds represented by the length of the ordinate at the same point.

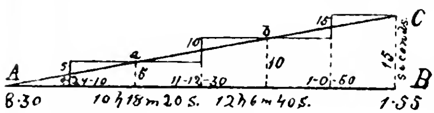


Fig. 7.

Now, I have taken the limit of error for the time, at 5 seconds, and hence at the point $a = A\,B \div 3$ we have the interval 5 h. 25 m. ÷ 3 = 1 h. 48 m. 20 s., which added to 8 h. 30 m., gives the time, 10 h. 18 m. 20 s., at which the watch is just 5 seconds too fast. And at 1 h. 48 m. 20 secs. more or 12 h. 6 m. 40 secs., it is just 10 seconds too fast. Now at points half way between these it is assumed that the watch

jumps in its indications 5 seconds, as shown by the jogged line, and continues for an equal distance on either side of the points A, a, b, and C, which give the true times of this increase. So that no correction is made, in this case, from 8.30 to 9.24, when 5 seconds are subtracted from all the readings till 11.13, when 10 seconds are subtracted, etc., and similar corrections were made for the other tables.[1]

Column 6. *Steam Pressure,—Gauge Readings.*—The gauge upon this engine was of the American Steam Gauge Company's make, a Bourdon Gauge with Lane's Improvement, and similar in all respects to that described and illustrated in Part I. The readings were taken as soon as possible after noting the times, and vary from three, five, to ten seconds only, behind time. It has been noticed since the readings were taken that with no steam raised in the boiler, the gauge hand indicated 6 or 8 lbs., but this is perhaps not unusual in locomotive gauges on account of the very stiff springs employed, to prevent the jarring of the engine from making the motion of the hand unsteady. In this column is seen the great and often sudden variations of pressure occurring in locomotives, it hardly remaining the same for two consecutive seconds. Where the steam is used almost as fast as generated, its sensitiveness to the coal thrown on the fire is apparent. The pressures used on the Eastern Road are nominally 140 lbs. for first class engines, to which class this engine belongs, and 120 lbs. for second class, the class of any engine depending upon the length of time the locomotive has been in service. The safety valves were set, one to blow off at 130 lbs., and the other at 135, and, in the tables, the variations from these pressures are seen. In several instances, the pressure rose to 144 lbs., and in one, the valve began to rise at 144½ lbs. (Table III), in another case in the same table closing at 133 lbs. In Table II, the pressure at Salem, rose 19 lbs. in 1 minute, 25 seconds.

From the averages for each trip of 56 miles we notice the difference produced in the steam pressure by the weather. On Wednesday, there being a strong wind, the average is lower for the return trip, as the wind was West and against the train; on the second day, it is about the same both ways, or 131 and 133 lbs. (Tables III and IV), and much higher than on the preceding day when it was 127 and 115 lbs.; and on the third day, it was 132 lbs. down, and but 119

[1] This method is similar to that followed in working up the results of a pumping engine test, at Providence, R. I., Dec., 1875.

TABLE IV.—Trip No. 4.

DATA AND RESULTS FROM HINKLEY ENGINE No. 55, EASTERN R. R., ON BANGOR TRAIN, RETURN TRIP.

Date: Thursday, March 16th, 1876.
Day: Weather, dry and pleasant.—Wind, W., breeze.

At Portsmouth:— Coal taken on, 2 tubs, @ 400 lbs., = 800 lbs.
Depth Water in Tender at starting, 42 inches.
Number of Cars, 6.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
			TIME RECORD.			COAL RECORD.			SPEED RECORD.						WATER AND STEAM RECORD.	
Miles from Portsmouth.	Train Due. Time.	STATION.	Train Arrivals and Leavings. Corrected time by watch.	Length of Stop.	Steam Pressure, Gauge Readings.	Weight fired between stations.	Aggregate weight.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile
	H. M.	Leave	H. M. S.	M. S.	LBS.	LBS.	LBS.			LBS.						LBS.
	A. M.		A. M.													
	11 18	Portsmouth	11 22 45		137†	189 0	189 0		6	123	250	4090	46 5†		25 515	
			ar. 33 55						6	120	180	2945	33 5†	26 3		318·4
5	11 28	*Greenland	11 34 10	15	130	108 0	297 0	22	6	118	180	2945	33 5†		14 580	
			ar. 39 45						10	117	150	2454	27 9†	19·5		454·9
7	11 35	North Hampton	11 40 20	35	127	54 0	351 0	22	6	114	210	3437	39 1†		7 290	
									10	124	90	1472	16 7†	27·3		151·6
10	11 42	Hampton	11 46 55	...	133	54 0	405 0	18	10	130	220	3600	40 9†		7·290	
									10	123	250	4090	46 5†	39 1		151 6
13	11 47	*Hampton Falls	11 51 30		129	108 0	513 0	18							14·580	
									......	....	......	......	....	12·0		909 8
14	11 50	*Seabrook	11 56 30		138	108 0	621·0	108	10	133	180	2945	33 5†		14·580	
			P. M.						6	130	220	3600	40 9†	29 3		303·3
17	P. M.	*Salisbury	12 02 40		125	40 5	661 5	36	6	127	260	4255	48 4†		5·468	
									......	....	......	......	....	30 0		170 6
19	12 05	Newburyport	12 06 40	...	137†	27 0	688 5	20	10						3 645	
		Know-nothing	... ...	...	134	54 0	742 5	27	10	....	......	......	....	17 3	7·290	227·4
22		*Knight's Crossing	12 17 05		133	128 3	870 8	32	6						17·321	
									6	129	200	3273	37·2†	37 9		270·2
26		*Rowley	12 23 25	...	134	135 0	1005 8	45	10						18·225	
			ar. 29 45						10	129	200	3273	37 2†	28 3		379 1
29	12 28	Ipswich	12 36 10	6 25	139	243 0	1248 8								35 235	
			ar. 46 00						10	130	220	3600	40 9†	28 8		439·7
34	12 40	Wenham	12 46 35	35	134	54·0	1302 8	49	10	129	220	3600	40 9†		7·830	
									10	122	220	3600	40 9†	32 7		244 3
36		*North Beverly	12 50 15		117	40 5	1343 3	27	10	118	210	3437	39 1†		5 873	
			ar. 54 45						6	126	290	4745	53 9†	26 7		183 2
38	12 48	Beverly	12 55 45	1 00	138	40 5	1383 8	20	10						5 873	
									......	....	200	3273	37·2†			
		Know-nothing	12 59 15	...	136	27 0	1410·8		10					18 5	3 915	305·4
			ar. 02 15													
40	12 58	Salem	1 05 15	3 00	141	108 0	1518 8	34	10	134	180	2945	33·5†		15·660	
									10	136	200	3273	37 2†	33·9		244 3
44		Swampscott	1 12 20			27 0	1545 8	27	6						3·915	
			ar. 14 40		146				......	....	......	......	....	25 7		244·3
45	1 11	Lynn	1 16 10	1 30	143	13 5	1559·3	27							1·958	
									......	....	......	......	....	24 0		122·2
46		West Lynn	1 18 40		....	67 5	1626·8	14	10	132	200	3273	37 2†		9·788	
									6	125	200	3273	37 2†			
		Oak Island	1 24 15		126	40·5	1667·3		6					31 6	5·873	244·3
									6	124	200	3273	37·2†			
50		Revere	1 26 15		124	81·0	1748 3	27	6						11·745	
			ar. 29 25						6	119	200	3273	37·2†	18 9		732·9
51	1 28	Chelsea	1 30 05	40	134	27 0	1775·3	81							3·915	
									10	....	......	......	....	34·9		122·2
53		Everett	1 33 30		122	......			6						....	
									6	134	240	3927	44·6†			
		Curve at Somerville	1 35 10		131	......			6					28·8	....	....
			ar. 35 35													
54		Somerville	1 37 50	2 15	142	54·0	1829 3	9	14						7·830	
		B. & M. R. R. Crossing														
		Prison Point	1 41 10	...	133	40·5	1869 8									
														26·1	5·873	427·6
							Tot. for 56 miles run,									
56	1 45	Arrive at Boston	1 42 25		......			52								
			Average steam pressure, 133 lb.				Av. lb. coal per mile, 34							Average, 27·2		Average, 316·5

* Flag Stations.

18. NOTES.

Oiling, Shutting Off, Braking, Stirring Fire, Air Brake Pressure, etc.

At Portsmouth, estimated coal in tender, before taking coal aboard, 6½ tubs † Safety valve blowing.
† Time, 11 29 00 Oil'd cylind's.
† Time, 11 31.00. Stirred fire.
† Up-grade. Time, 11.32 00.
At 33.10 shut off steam; 5 secs. later put reverse lever forw'rd & stopp'd at 33.55 Stirred fire.
† Up-grade. Time, 11.36 00. Stirred fire.
† At bridge. Time, 11 37.30.
† Heavy up-grade. Time, 11.42.00.
† Time, 11 44.00. At 33.10.
† Time, 11.45.00.
Shut off at 39.00, link forward, 39 05; stop'd at 39.45, in 45 secs., from full speed. Stirred fire.
† Up-grade. Time, 11 58.00.
† Level Time, 12 00 M.
† Time, 12.01.00.
At Newburyport, depth water in tender, 30⅜ in. when still.
† Valve blowing. Taken at 12.09.50
Oiled cylinders.
Stirred fire.
† Up-grade. Time, 12.19.00.
Stirred fire. Made a stop.
† Time, 12.26.00.
At Ipswich: Depth water, before filling, 24½ in.; after filling, [full.
† Time, 12.41.00. Second valve blew off at 144 lbs.
† Time, 12.42.00.
† Up-grade. Time, 12.49.00.
† Time, 12.50.00.
† Down-grade of 43 ft. to a mile. Time, 12.53.00.
† Speed taken while slowing down. Time, 12.58.00.
Stirred fire.
At Salem, depth water, 33¾ in.
† Time, 1.08.00.
† Time, 1.09.00.
† At long bridge. Time, as corrected, 1.20.20.
† At bridge. Time, 1.22.00.
† Time, 1.24.00.
Stirred fire.
† Time, 1.27.00.
Stirred fire.
† Corrected time, 1.33.50.
Stirred fire.
Oiled cylinders
Watch 20 secs. slow at 1.45 P. M. Depth of water in tender on arrival, 26 inches.

TABLE V.—Trip No. 5.

DATA AND RESULTS FROM HINKLEY ENGINE, No. 55, EASTERN R. R., ON 8.30 A. M. BANGOR TRAIN, DOWN TRIP.

Date: Friday, March 17th, 1876.
Day: Weather, sleety: rain, wet, icy and slippery: Wind, E.

At Boston: *Coal in Tender at starting, tender full, estimated, 15 tubs @ 400 lbs. = 6000 lbs.*
Depth Water in Tender at starting, 41 inches.
Number of Cars, 8, same as on Wednesday.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			TIME RECORD.			COAL RECORD.			SPEED RECORD.						WATER AND STEAM RECORD.		NOTES.
Miles from Boston.	Train Due. Time.	STATION.	Train Arrivals and Leavings. Corrected time by watch.	Length of Stop.	Steam Pressure. Gauge Readings.	Weight fired between stations.	Aggregate weight.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile	Oiling, Shutting Off, Braking, Stirring Fire, Air Brake Pressure, etc.
	H. M.	Leave	H. M. S.	M. S.	LBS.	LBS.	LBS.			LBS.						LBS.	
	A. M.		A. M.														
	8 30	Boston	8 31 20		134	54·0	54·0								4·158		Watch 10 seconds slow at 8.28 A.M.
		Prison Point	8 34 00	...	133	81·0	135·0								6·237		Oiled cylinders.
														18·2		389·2	
		B. & M. R. R. Crossing.	8 36 35	...	142½†	27·0	162·0								2·079		† Valve blowing.
2		Somerville	8 37 55		142	67·5	220·5		10						5·198		
		Curve at Somerville	8 39 10		141	54·0	283·5	115	10					18·0	4·158	583·8	
									10	132	220	3600	40·9†				† Time, 8.40.00.
3		Everett	8 41 15		131	94·5	378·0	54	10						7·277		
									10	127	270	4418	50·2†	32·7		227·0	† Time. 8.42.00.
5	8 42	Chelsea	8 44 35	..	140†	67·5	445·5	47	10						5·198		Stirred fire.
									10	125	180	2945	33·5†	15·0		324·4	† Time, 8.47.00.
6		Revere	8 48 35		136	67·5	513·0	68	10						5·198		† Valve blowing.
									10	127½	240	3927	44·6†				† Time, 8.50.00.
		Oak Island.	8 51 15		127	67·5	580·5							37·5	5·198	162·2	
									10	124	240	3927	44·6†				† Time, 8 53 00. At end of taking speed were at long bridge.
10		West Lynn	8 55 00		119	....		34	10						....		
			ar. 56 45											34·3		....	Stopped from full speed in 1 min. 10 secs.
11	8 59	Lynn	8 59 30	2 45	139†	148·0	728·5	00	14						11·396		Stirred fire.
														16·4		711·1	
12		Swampscott.	9 03 10		114	148·0	876·5	148	10						11·396		† Valve began to blow at 144 lbs., and was still
			ar. 09 50		124				10	102	190	3168	35·3†	36·0		177·8	† Time, 9.5.00. [blowing at 139 lbs. at starting.
16	9 12	Salem	9 12 30	2 40	140	81·0	957·5	37	10	102	200	3273	37·2†		6·237		† Time, 9.5.30. At Salem, oiled cylinders and
																	At 9 7 40, shut off by throttle. [engine outside.
		Know-nothing.	9 15 00	...	134	81·0	1038·5		10					17·3	6·237	389·2	At 9 7 44, reverse rod put forward.
			ar. 19 25		131												At 9 7.50, brake put on.
18	9 2	Beverly	9 20 10	45	137†	162 0	1200·5	81	10						12·474		† Valve blowing. Stirred fire.
			ar. 26 40						10	121	160	2618	29·8†	18·5		389·2	† Heavy up-grade, time, 9.22.00.
20	9 26	*North Beverly	9 27 00	20	124	108·0	1308·5	81	17						8·316		Stirred fire.
			ar. 31 35						10	118	184	3010	34·2†	26·1		259·5	† A long and heavy up-grade, time, 9.27.00.
22	9 32	Wenham	9 32 10	35	139	222·8	1531·3	54	14						17·156		
			ar. 41 30		133				10	128	260	4255	48·4†	32·1		214·0	† Time, 9.37.00.
27	9 43	Ipswich	9 44 10	2 40	133	202·5	1733·8	46	6	120	230	3764	42·8†		20·756		† Time, 9 39.00.
									10	109	260	4255	48·4†	22·1		431·7	† Time, 9.50.00.
30	9 50	*Rowley	9 52 20		134	87·8	1821·6	68	10						9·000		
									10	107	190	3108	35·3†	33·9		140·4	† Up-grade, time, 9.56.00.
34		*Knight's Crossing	9 59 25		100	94·5	1916·1	22	10						9·686		Stirred fire.
																	Stirred fire.
		Know-nothing	10 03 00	...	117	128·3	2044·4							23·6	13·151	475·0	
			ar. 07 00														At Newburyport, depth water in tender, 34¾
37	10 05	Newburyport	10 09 20	2 20	136	148·5	2192·9	74	10						15·221		inches.
									10	121	230	3764	42·8†	26·7		474·9	† Time, 10.13.00.
39		*Salisbury	10 13 50		119	121·5	2314·4	72	10						12·454		Stirred fire.
			ar. 20 00						10	110	160	2618	29·8†	29·2		259·0	† Heavy up-grade, time, 10.17.00.
42	10 20	*Seabrook	10 20 25	25	124	175·5	2489 9	41							17·989		
														14·1		1091 0	Opened back ash pan damper.
43	10 25	*Hampton Falls	10 24 40		138†	108·0	2597·9	176	6	125	110	1800	20·5†		11·070		† Valve blowing. Stirred fire.
			ar. 30 15						21⅛					20·9		230·3	† Very heavy up-grade, time, 10.29.30.
46	10 35	Hampton	10 32 00	1 45	141	162·0	2759·9	36	17						16·605		
			ar. 39 05						14	132	96	1571	17·9†	25·3		345·4	† Time, 10.34.30.
49	10 40	North Hampton	10 39 45	40	138	108·0	2867·9	54	10						11·070		Oiled cylinders. Stirred fire.
									10	124	170	2781	31·6†	19·5		345·4	† Speed taken at stone overhead bridge, time, [10.43.00.
51	10 47	*Greenland	10 45 55		141†	189·0	3056·9	54	10						19·373		† Valve blowing.
																	Oiled cylinders. Stirred fire.
							Tot. for 56 miles run.										
		Arrive at							10	118	200	3273	37·2†	27·9		241·8	† Down-grade, time, 10 50.00
56	10 57	Portsmouth	10 56 40		125			38	10	117	110	1800	20·5†				† Time, 10 55 15, and taken for ¼ minute. Bent draw pin.
			Average steam pressure,		132 lbs.	Av. lb. coal per mile,		64					Average,	24·8	Average,	374·4	At Portsmouth: Depth water before filling, 21 ins. Depth water after filling, 41½ ins.

* Flag Stations.

on the return trip, the wind, as we see, affecting it very much on the exposed portions of the road.

Column 7. *Coal Record; Weight fired between Stations.*—This was found in what may be considered, perhaps, a very rough manner. The times of firing between every two stations, were noted, in number, and the equivalent number of full shovels of coal thrown in at each time estimated. That is, the fireman would throw in from one to three shovelfuls at a time, and then, in perhaps half a minute more, two more, etc., and whether these amounted to $1\frac{1}{2}$ or 2 *full* shovels, was estimated and noted, and after a little practice this could be done quite accurately. We see also that the relative quantities thrown in at different parts of the road are known, if not the absolute, for practically the firing was quite even.

The shovel, full of coal, was weighed on scales before starting, the coal was in the same condition as to dampness as when used on the road, and the record reads:—

Weight of the shovel *full* of coal, . .	21	lbs.
" " empty, . . .	$7\frac{1}{2}$	"
Weight of coal contained in one shovelful,	$13\frac{1}{2}$	lbs.

The coal record was obtained, using this number, which was verified by several weighings.

Column 8, the *Aggregate Weight* of coal fired, shows the great variation in the amount burned in doing the same work on consecutive days. The differences in the conditions were those of the wind and weather. On Wednesday, during the down trip, nearly half a ton more coal was burned, than on Thursday, and on Friday, 1133 lbs. more. We had the same fireman on Wednesday and Friday, but a different one on Thursday. Whether the predominating influence was that of the wind or the fireman, is a question I do not attempt to decide.

Column 9 shows the same variation.

Column 10. *Cut-off.*—This column is intended to give a general idea only, of the point at which the steam was cut off in the cylinder. The reverse quadrant had its notches marked as given in Fig. 114, Plate D.

Columns 12, 13 and 14. *Speed Observed.*—This was obtained by counting the number of revolutions made by the driving wheels in one-half minute, and multiplying this by two we obtain the number of

revolutions per minute shown in column 12. In taking the speed a full minute was not used on account of the liability of losing the count, and because of the fact that the speed was constantly changing and also the character of the road. It was the intention to take the maximum speed at least once between each two stations. This was done as follows.

When it was thought that the engine was at its maximum speed the time was noted, about ten seconds before an even minute. A straight piece of track was also selected, or, sometimes, a heavy grade. Precisely on the even minute, watch in hand, the counting was commenced, and after a little practice, the watch could be glanced at to see whether the time was out or not, and the counting continued mentally without missing a count. At the end, the number was set down, then the steam pressure, as quickly as it could be read, the number of the cut-off notch, and any remark, if taken on an exceptional grade.

The feet traveled per minute, column 13, were found by multiplying the number of revolutions by the circumference of the driving wheels, viz., $2 \pi r = \pi d = 3{\cdot}1416 \times 62{\cdot}5 = 16{\cdot}36$ feet, and the rate in miles per hour, column 14, by multiplying the feet traveled per minute by 60, to obtain the feet per hour, and dividing by 5280, the number of feet in a mile.

Column 15. *Average Speed between Stations.*—In computing this, the difference of the times was taken, reduced to seconds, divided by the number of miles between the stations, which gave the number of seconds in which one mile was run; and 3600, the number of seconds in an hour divided by it, which gave the average rate in miles per hour. Where the time of stopping was noted, that is taken in computing the average speed, and hence the total averages per trip will be found to exceed that calculated from the time of the whole trip.

The highest average speed during any of the trips (throwing aside that in Table I, which is doubtful) is that between Hampton and Hampton Falls, a distance of 3 miles, on Thursday (Table IV), when 39·1 miles per hour were attained. This was on a heavy down grade, as the other tables show, of 43 feet to the mile.

In the column of maximum rates there are three that indicate a speed of over 50 miles per hour,—50·2 miles (Table V), 53·9 (Table IV), and 67·0 (Table VI). The last rate being so exceptional, the circumstances attending it may be mentioned. The track was that

portion between North Beverly and Beverly, which has a down grade of about 40 feet to the mile, the cut-off was at 6 inches of the stroke, and the throttle wide open. It will be noticed that 360 revolutions in a minute, or 90 in one-fourth minute, is about as fast as a person can count. In fact this, equal to six times per second, could not have been audibly counted, but was partly estimated. The number of turns could be estimated by the eye when, perhaps, they could not be counted, and the high speed obtained immediately afterward which serves as a check, leaves no doubt, I think, that this speed was actually realized. It was calculated as follows: $16{\cdot}36 \times 360 = 5889{\cdot}6$ feet per minute. To this, as the speed was over 200 revs., 1 foot is to be added to make up for decimal places omitted, viz., 16·3625. Therefore, $5889{\cdot}6 + 1 = 5891$, which multiplied by 60 gives 353,760 as the feet per hour, and dividing this by 5280 we obtain 67 miles per hour. In all calculations in this thesis, it may be mentioned, that whenever the rejected decimal places were one-half, ·5, or over that of the next figure preceding, the next larger number has been invariably taken.

Columns 16 and 17. *Water and Steam Record.*—The datum taken by which this has been obtained was the depth of water in the tender at several points along the road. This was obtained, on the first day, by inserting the handle of the fireman's broom into the manhole of the tender and then measuring the length of the part wet. Afterwards a notched stick, graduated to quarters of inches, was used, with an increase of accuracy.

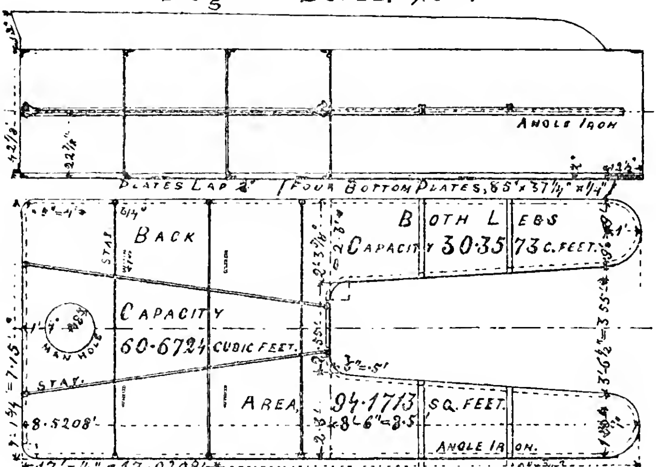
To make these observations of any use, it was of great importance that the capacity of the tender should be accurately determined.

The following diagram indicates the result finally determined upon, and shows also the construction and internal bracing of the tank.

The tender of this engine is of unusual length and capacity; the tank, nominally of 2500 gallons capacity, being nearly a foot longer than the ordinary tank of 2000 gallons. To obtain its capacity with the greater accuracy, the working drawings were used, access being had to them at the Hinkley Works, and *in addition*, actual measurements were taken with a steel tape of every accessible part. These, the more important of which were repeated several times, have been mainly followed in calculating its capacity, and those upon the drawings have served rather as checks. The area of the back was found to be 60·8551 sq. ft., as follows:—area back = area rectangle, 8·5208 ft. $\times$ 7·15 ft., diminished by the difference between the areas of a quad-

rant of a circle of a radius, $r = \cdot 4$ ft., at corners, and of a square of $\cdot 4$ ft. side $= 60{\cdot}9237$ sq. ft. $- 2\,[(\cdot 4 \times \cdot 4 \text{ ft.}) - \frac{1}{4}\pi r^2] = 60{\cdot}9237$ sq. ft. $- 2\,(\cdot 16$ sq. ft. $- \cdot 1257$ sq. ft.$) = 60{\cdot}8551$ sq. ft. In the same manner the area of the other parts was found, correcting for the curved portions. Multiplying by the height, $42\frac{7}{8}$ inches $= 3{\cdot}572$ ft., the gross number of cubic feet in the tank was found to be 336·3799. According to Haswell's Engineer's Pocket Book, "the standard gallon equals 231 cubic inches, and contains 8·33888 lbs. of distilled water, at its maximum density, 39·1° Fahr., the barometer being at

TANK OF HINKLEY ENGINE No. 55, E.R.R.
FIG. 8 — SCALE. 3/16" = 1'.



(CORRECTED CAPACITY OF TANK, 2502·4 STANDARD GALLONS.)

30 inches." Hence there are $\frac{1728}{231} = 7{\cdot}4805$ gallons in a cubic foot. Multiplying our result by this, the gross capacity of the tank is 2516·2898 gallons.

(To be continued.)

The Electric Light Apparatus.—The work of fitting the electric light apparatus on board the *Alexandra* is now complete. By means of this light (on the mizzen mast), it is stated that when at sea very small objects will be distinguishable some two or three miles distant.—*Telegraphic Journal.*

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* By measurement.

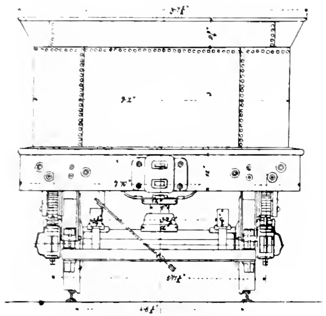

Fig. 4. REAR VIEW.

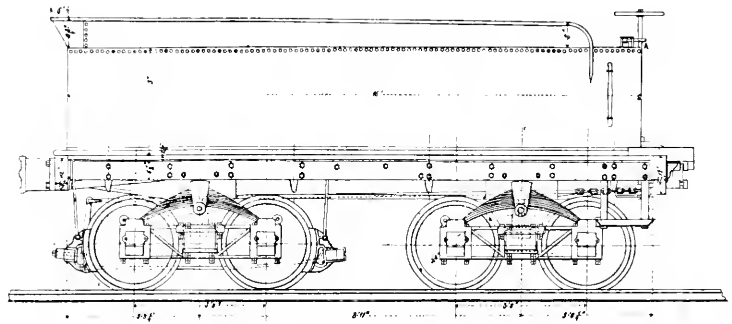

Fig. 1. SIDE ELEVATION.

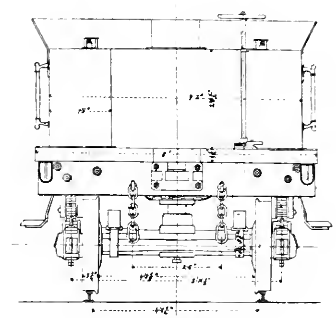

Fig. 2. FRONT VIEW.

TENDER
for the
HINKLEY PASSENGER LOCOMOTIVE
BOSTON
MASS.

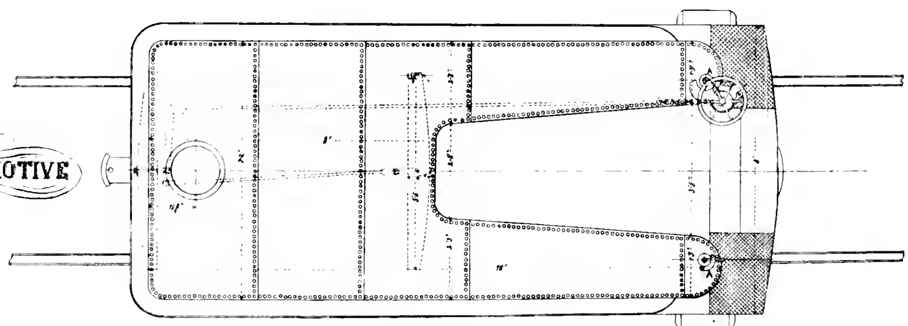

Fig. 3 PLAN.

Francis E. Galloupe.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS, DURING THE LAST TEN YEARS.[1]

By Dr. A. W. Hofmann.

From the *Chemical News*.

[Continued from Vol. ciii, page 216.]

Hitherto horse or cart galleries have only been introduced in four solfares, those of Montagna Vecchia (Province of Aragona), San Giovanello, and Montelonge (Province Casteltermini), and Galleria Ercole (Province Sommatino). According to statistical returns collected in 1865 this system has shown very favorable results.

The first attempts at raising the ore by means of shafts were made at a solfare in the district of Respica (Province Villarosa), and in another on the Colle di Madore (Province of Lercara), by a French mining engineer named De Labretoigne. They were carried on intermittently from 1859 to 1861, but the result was so unsatisfactory that they were given up. In 1865 similar experiments were made at the Solfare of Montedore, but with no better issue; and not until 1868 was the use of shafts seriously taken in hand and successfully carried out. This took place at the Solfare of Grottacalda, at that time under the management of the mining engineer Parodi, from whose report we take this brief extract. Here the shafts proved so advantageous that the same system was soon introduced in the solfares of Floristella, of Gallizzi, and in others of less importance. The new arrangement at Grottacalda cost 78,000 lire; the shaft is 137 metres in depth, and has been in use for raising the ore since 1871. Since 1872 a steam-engine of 40 horse power has been working in the great solfara of Sommatino. At the same time shafts were commenced at the solfaras of Raddassa, Montagna (Province Sommatino), and Trabonella in the neighborhood of Sanatra (Province of Caltanisetta), exclusively destined, however, for the removal of water. In place of the wooden pumps formerly in use, metal pumps have been already introduced, which are managed by workmen named *trombatori*.

If we compare the returns of the year 1867 with those of 1871 very notable progress will be perceived. Whilst at the end of 1867,

[1] "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

13 solfaras only employed 20 steam-engines, with a collective power of 256 horses, in 1872 21 solfaras are working with 400 horse power. In the construction of the engines, which are now built on scientific principles, great improvements have been made.

At the mouth of the sulphur mine, each picconiero with the help of his manuali, throws the ore he has raised into a heap (*catasta*), which is then measured by specially appointed officials (*catastieri dell' amminestrazione*). As a unity of measurement the *cassa* is employed, a vessel of the form of a parallelopipedon which, in different mines, holds from 2·5 to 5 cubic metres.

The extraction of the sulphur in Sicily is almost exclusively effected by fusion. The eliquefaction in small cast-iron apparatus (called *doppioni*, because they are fixed in pairs, retort and receiver) as is customary in some solfaras of the Romagna, or in earthen vessels (*pignatti di argilla*), as described in manuals of chemistry, has never been in use in Sicily. As far back as tradition extends very primitive arrangements have been in use in the island, known as *calcarelle*.

For this purpose round holes were dug in the ground of about 2·5 metres in diameter and 4 decimetres in depth, in the midst of which the *picconieri* piled up the sulphur ores in a high mound—an operation which generally took up two days. This heap was set on fire in the evening, and in the morning of the next day so much liquid sulphur has collected in the outer part of the hole that it can be scooped out and cast into rolls—an operation which lasts till evening, and is resumed on the following day. This process involved little outlay, but the yield was small. Only one-third of the sulphur in the ores was utilized, the remaining two-thirds being diffused in the atmosphere as sulphurous acid, to the annoyance of the inhabitants, and to the serious injury of the adjacent fields.

Since 1850 the eliquation of sulphur in Sicily has been materially improved by the conversion of the *calcurelle* into *calcaroni*. The latter, as the word itself implies, are merely excavations like those described above, but on a much larger scale, and of an improved construction. They are large round cavities of a semicircular or semi-elliptical section, of about 10 metres in diameter and 2·5 metres in depth. They are generally contrived in places where the slope of the ground renders it practicable to arrange a communication from without with the lower part of the calcarone, the bottom of which is made

inclining to this point. This external communication, curiously known as *la morte*, consists in an aperture 1·20 metres high and 25 centimetres broad. Within the *calcarone* is lined with a wall of gypsum, from 4 to 5 decimetres in thickness at the back (*i.e.* the part furthest from the opening), but from 1 to 1·2 metres at the front. The masonry is lined with a smooth layer of gypsum, impenetrable by melted sulphur.

The *calcarone* is charged by workmen known as *riempitori*. The cover, the bottom—which is either the mere ground, or, preferably, a hearth formed of hewn stone—first with a layer of finely ground burnt ore from former operations (*ginese*), upon which follows a stratum of larger lumps of ore (*tozzi*). Upon this foundation the ore is heaped up, care being taken to put the smaller pieces principally on the outside of the heap. At the same time the outer communication is blocked up with a kind of vault (*porte*), which is built up with large blocks of the poorest ore about its internal aperture. As soon as the cavity is filled up to the margin the workmen pile up more ore, forming a mound of the shape of a blunted cone (*colmatura*, *cucuzzo*), still keeping the larger blocks in the centre, and the smaller about the circumference. By means of the large blocks it is found practicable to leave vertical chimney-like openings in various places, not too far from the margin, and especially at the back of the *calcarone* in order to regulate the draught. The mound is then covered with a stratum of finest powdered ore (*sterro*), over which follows lastly a coating of ground burnt ore (*ginese*) and known as the *shirt* of the heap (*camicia*). Before igniting the *calcarone* the outward aperture is closed with a thin wall of gypsum, in which small holes are left at various heights, and are closed during the combustion with balls of clay. The heap is kindled by means of bundles of straw dipped in sulphur and thrown into the draught flues. After about one hour all apertures are closed, and the mound is left to itself for eight or nine days. Then mingled vapors of water, sulphur and sulphurous acid begin to make their way through the outer coating of the heap, and around the flues their appears a slight sublimate of sulphur. At the same time the barrier of the outward aperture becomes hotter and hotter near the ground, and finally red hot. By opening one of the holes which had been stoppered with clay, it is possible to ascertain whether a sufficient quantity of melted sulphur—*olio* as the workmen call it, has collected at the bottom of the furnace. Now begins the work of the sulphur-casters

(*arditori*); with a pointed iron bar (*spiedo*) they perforate the lower part of the gypsum wall, and collect the melted sulphur in moistened moulds of poplar wood (*gavite*) of the shape of a blunted pyramid. In this manner blocks of from 50 to 60 kilos. (*balate*) are obtained, and are sent to market without further preparation. The tapping and casting the sulphur are not everywhere conducted in the same manner. In some works the sulphur is allowed to collect till the end of the entire combustion, and run off at once, but generally the *calcarone* is tapped twice or thrice in the course of 24 hours, so as to remove the sulphur as it collects. The *calcarone* is emptied and prepared for a fresh charge by workmen known as *scalcaratori*.

The duration of the process, from the commencement of charging till the last roll of sulphur has been cast, varies with the capacity of the furnace, the nature of the ore, and the condition of the atmosphere. In furnaces of equal size the operation is the more prolonged the denser the ore and the colder the weather. Wind promotes whilst rain retards the combustion. On an average we may assume that the melting requires, for furnaces containing:—

50 to 60 cassas, . . .	30 to 35 days.
200 " 250 " . . .	50 " 60 "
400 " 500 " . . .	80 " 90 "

Both in the calcarone and in the calcarella a part of the sulphur is burned, in order to furnish the heat required for the fusion of the rest. The consumption of sulphur for this purpose fluctuates greatly and depends on very various conditions. It is particularly large if the ore is very gypsiferous and contains, consequently, much water, or if it has been placed in the furnace when moist, or if violent rains have fallen during the burning. In long continued rains an operation sometimes miscarries entirely. In a successful operation with an ore containing 25 per cent. of sulphur, 70 per cent. of marly limestone, and 5 of water, theoretically, the combustion of $\frac{1}{5}$ of the sulphur should be sufficient, but in practice $\frac{1}{3}$ and even $\frac{2}{5}$ are consumed.

It need scarcely be mentioned that methods have been proposed to obviate this loss, and especially to protect the neighboring population against the pernicious influence of an atmosphere polluted with sulphurous acid.

At Lercara, where, for a length of time, very rich ores (*talamone*) were exclusively obtained very friable, and, therefore, unsuitable for burning in calcaroni, the fusion has long been conducted in open cast-iron pans, of semicircular section, heated by means of vegetable fuel. The expense of melting amounted to 2·50 lire per 100 kilos. In each operation 8 to 9 quintals of sulphur were obtained, and 2 to 3 quintals of fuel consumed. The pans served from four to five years. At the sulphur mines of Madora (Province Lercara), where very poor ores are worked, this method is not applicable. Durand introduced there the furnace bearing his name. It consists of a quadrangular chamber of masonry, each side measuring 2 metres, with a sloping bottom and a vaulted roof, in the midst of which is an opening for charging and emptying the furnace. In the lower part of the front wall is the tap hole, and in each side is an aperture, the one to kindle the furnace and the other to remove the products of combustion. In such a furnace containing 1½ cassas, a fusion (including the time for charging and emptying) lasts twenty-four hours. The process is otherwise conducted as in the calcarone.

Another furnace was built in 1861 by Conrad Hirzel, at the Solfara Col di Serio, in the province of Lercara. By means of this apparatus, which was patented by the inventor, the fusion is effected more rapidly, and every loss, whether by sublimation or by combustion of the mineral, is said to be avoided. But this arrangement, though ingenious, is complicated, and the result has generally not come up to expectation, so that after two years the furnace has been abandoned. An apparatus introduced almost simultaneously by Joseph Gill, at the Solfara della Croce (Lercara), which was to effect the fusion of the sulphur by means of hot air deprived of oxygen, as also the system devised by Heinrich Keyser, for extracting the sulphur by sublimation in cast-iron or earthen retorts, have met with no better fate. The latter process seems at the best merely serviceable for the treatment of very rich powdered ore (*sterri*), and only for the manufacture of flowers of sulphur.

The proposal of H. Condy Bell (1867), to extract the ores in the moist way with the bisulphide of carbon has not been successful. According to experiments made in 1868 at Bagnoli, near Naples, insurmountable difficulties were met with in the attempt to carry out the process on the large scale.

We must also mention the attempts at extracting the sulphur by means of high-pressure steam. The suggestion was made many years ago by Joseph Gill, but experiments on the large scale were first undertaken by Thomas at Palermo, in 1868. The process has been patented by a company, the *Societa privelegiata per la fusione dello solfo, in Italia.*[1] The process requires the use of ordinary fuel. Steam is used at a tension corresponding to the melting point of sulphur. Theoretically a pressure of 2 atmospheres should suffice; practically from 3 to 3½ atmospheres are required. A higher pressure would impair the quality of the sulphur.

Not more than 6 or 7 fusions daily can be effected by means of this system, 2 tons being treated each time. In a successful operation not more than 5 per cent. of the sulphur originally present remains in the residue, so that an ore of 22 per cent. on fusion in steam yields 21 per cent., whilst the process in the calcarone yields merely 15 per cent. This increased production approximately covers the working expenses. Still it must be remembered that Sicily possesses no fuel, and that 60 *lire* is no unusual price for a ton of imported coal. The metal apparatus required is also expensive, not to mention the outlay for the importation of machinery. For the present it must remain undecided whether the steam fusion process is calculated to supersede the old method. For the treatment of very poor ores the former seems already more advantageous. The company above mentioned have undertaken the fusion of the ores on their own account, taking as payment a percentage of the yield, whilst the rest remains the property of the mine owner. This percentage varies according to the nature of the ore; at della Croce it is 32 per cent., but in Madore, Montedoro, and Sommatino only 29.

It must not be forgotten that on account of the different nature of the material operated on, the results in different mines vary greatly. Hence in some places where the new process had been introduced it has been again abandoned, whilst in others its retention is still doubtful.

The purification of sulphur is still principally carried on in France, especially in the neighborhood of Marseilles. In Sicily there are only two or three refineries (at Catania and Porto Empedocle), which only work at intervals and on a small scale.

[1] Compare also the essay on the utilization of alkali waste (regeneration of the sulphur) in a subsequent portion of this report.

Manufacture of Sulphuric Acid.

By Robert Hasenclever, Manager of the Stolberg Works.

In few branches of chemical technology is it possible to show an amount of progress equal to what has taken place in the manufacture of sulphuric acid during the last ten years. On the one hand, the production has been greatly augmented in consequence of the increased manufacture of soda, potash, by the preparation of artificial alizarin, nitro-glycerine, etc. On the other hand, the process of the manufacture of sulphuric acid has undergone essential alterations.

Whilst former investigations were chiefly undertaken in the hope of discovering new methods of procedure and new apparatus for the manufacture of sulphuric acid, attention has latterly been merely directed towards the discovery of new sources of sulphurous acid, of improved kilns, and of a theoretical elucidation of the process in the lead chambers—in use now for a century—with a view to its practical improvement.

Besides the memoirs of various chemists and technologists in the scientific journals the following works on the manufacture of sulphuric acid have appeared:—

1. M. J. Kolb, "Etude sur la Fabrication de l'acide Sulfurique Considerée au point de vue Theorique et Technologique." Lille, 1865. (Study on the manufacture of sulphuric acid considered from a theoretical and technological point of view.)

2. Dr. C. A. Winkler, "Untersuchungen über die Chemischen Vorgänge in den Gay-Lussac'schen Condensationsapparaten der Scwefelsäure-Fabriken." Freiburg, 1867. (Researches on the chemical processes in the Gay-Lussac columns in sulphuric acid works.)

3. "Handbuch der Chemischen Technologie. Herausgegeben von P. A. Bolley, band ii, 1. gruppe, von Dr. P. Schwarzenberg." Braunschweig, 1869. (Handbook of technological chemistry, edited by P. A. Bolley, vol. ii, group 1, by Dr. P. Schwarzenberg.)

4. F. Bode, "Beiträge zur Theorie und Praxis der Schwefelsäure-Fabrikation." Berlin, 1872. (Contributions to the theory and practice of the manufacture of sulphuric acid.)

5. Henry Arthur Smith, "The Chemistry of the Sulphuric Acid Manufacture." London, 1873. (A German version by Fr. Bode, appeared at Freiburg, 1874.)

6. Lorenzo Parodi, "Sull' Estrazione Dello Solfo in Sicilia, e Sugli Usi Industriali del Medesimo." Firenze, 1873. (On the extraction of sulphur in Sicily, and on its industrial uses.)

The number of the compounds of sulphur applicable in the manufacture of sulphuric acid has considerably increased in the last ten years. Sulphur is only used in a few establishments; the chief material being iron pyrites, and in certain cases galena, sulphuret of copper, copper pyrites, blende, and Laming's mass.

Concerning new arrangements of the sulphur kilns nothing has been published. We must remark, however, that in certain works the pyrites furnaces have been converted into sulphur burners by the simple substitution of plates of cast iron for the grate bars in consequence of the high price of pyrites in the years 1871—1873. Heidenreich, of Hanover, first converted his furnaces in the manner above mentioned, and burnt in twenty-four hours 120 kilos. of sulphur per square metre.

In Stettin, Hamburg, and other places, sulphuric acid has been latterly made from sulphur in place of pyrites. But with the fall in the price of the latter the use of sulphur has again been abandoned.

The export of sulphur from Sicily has latterly reached the figures given in the subjoined table:—

1862	143,323 tons.
1863	147,035 "
1864	139,841 "
1865	138,232 "
1866	179,110 "
1867	192,320 "
1868	172,387 "
1869	170,141 "
1870	172,751 "
1871	171,236 "

For many years sulphur has been largely used in the vineyards of France, Italy and Spain as a remedy for the grape disease. The increased production of gunpowder and ultramarine requires likewise great quantities of sulphur, so that the decreased consumption of sulphur due to the use of pyrites in the manufacture of sulphuric acid has scarcely depressed the exportation from Sicily.

Roasting Pyrites.—The application of iron pyrites for the manufacture of sulphuric acid is now almost universal, and the extraction of this mineral has greatly increased in the last ten years. The

largest quantity is consumed in England, and comes from Spain, Portugal, and Norway. The imports of iron pyrites and Sulphur into Great Britain amounted in tons to:—

	Pyrites from—								Sulphur from
Date.	Norway.	Germany.	Belgium.	Portugal.	Spain.	Italy.	Sundry Places.	Sum Total.	Sicily.
1862	4,975	6,817	9,860	53,296	33,717	——	2187	110,852	54,200
1863	6,736	15,409	12,059	109,180	33,213	——	2628	179.225	43 060
1864	16,087	12,751	7,069	118,489	15,529	——	1065	170,990	40,420
1865	22,229	14,727	2,121	137,787	16,393	——	369	193,626	49,840
1866	38,262	21,574	4,006	165,993	11,910	——	1625	244,596	62,850
1867	77.895	34,592	2,299	105,556	50,222	——	2134	272,698	59,270
1868	63.007	41,559	——	75,883	47,458	794	1019	229,720	64,080
1869	63,091	13,983	——	140,805	99,648	——	2420	319,947	51,580
1870	67,464	14,914	——	174,459	150,996	——	3676	411,512	54,120
1871	74.416	12,809	——	120,573	242,163	——	4581	454,542	——
1872	71,665	5,682	——	180,329	257,429	——	2521	517,626	——

France derives its supply of pyrites chiefly from Chessy and Saint Bel, near Lyons; in the north, Belgian ores are used in small quantities. The pyrites consumed in Germany are chiefly produced from the "Sicilia" and "Siegena" mines, near Siegen; certain Rhenish mines produce also small quantities, such as the deposit of fine pyrites at Schwelm, Rammelsberg in the Harz district, etc.

The production of pyrites (in tons) in the following mines, amounted to:—

	Belgium	Chessy and Saint Bel, near Lyons.	Goslar.	Siegen.	Total Prussian mines except Siegen & Goslar.
1862	——	45,973	——	14,850	7461
1863	36,244	59,699	——	28,765	5934
1864	29,956	61,103	——	29,115	3437
1865	31,818	63,538	——	34,060	4187
1866	55,004	65,222	——	50,875	4302
1867	41,298	75,653	1599	71,835	4756
1868	37,933	75,656	2635	90,100	3953
1869	31,670	91,020	2689	64,789	6394
1870	28,665	63,464	3225	92,048	3191
1871	42.272	68,797	3324	110.432	4574
1872	40,932	99.000	3640	144,745	964
1873	——	127,000	1217	123,172	3748

The furnaces used in roasting iron pyrites vary according as they are intended for lumps, coarse, or small. The burners for lumps agree generally in the point that the ore is roasted on iron grate bars. The kilns employed in England have been repeatedly described—recently by H. A. Smith—and illustrated by diagrams. The indi-

vidual furnaces are separated from each other by small vaults, and are connected in such a manner that the gases escaping into the lead chambers may have an approximately constant amount of sulphurous acid. Each compartment is closed below by a separate door, at which the spent ores are removed. These doors are closed when a fresh charge of pyrites is introduced into the kiln from above, whereby the escape of any considerable quantity of sulphurous acid during the opening of the upper door is prevented. If the difference of level between the kiln and the flue leading the gases into the chamber is considerable, air is drawn in and no sulphurous acid can escape on opening the working door.

(To be continued.)

INVENTIONS OF THE CENTURY.

[Abstract of the first lecture in Prof. Pliny E. Chase's course, on "Lessons of the Centennial," delivered before the Franklin Institute, March 6th, 1877.]

You will not expect me to rehearse in three lectures any considerable portion of the lessons which could be learned by six months' study of the great Exhibition; but you may, perhaps, be interested in briefly reviewing a few of its most obvious teachings. I will ask you to-night to go back, in imagination, to the "good old times" of our grandfathers and great-grandfathers; to the generation which rejoiced in the enterprise of Franklin, who, as Deputy Postmaster General, had established a fast mail line, enabling a merchant or a stock broker or a lover, in Philadelphia, to send a letter to New York and get an answer in a week. There were no friction matches then. Man, as a cooking animal, had so far advanced from savagery as to substitute the flint and steel and tinder-box for the friction of two pieces of dry wood, as a means of procuring the fire that he needed. Matches, dipped in sulphur, served to start a flame from the tinder spark.

The German chemist, Döbereiner, found that platinum sponge *occludes*, or shuts up, many times its own volume of hydrogen. The rapid vibration of the gaseous particles being thus greatly concentrated, the frequent collisions raise the platinum to a glowing heat,

which inflames the gas that surrounds or plays upon it. This discovery led to the invention of his chemical lamp, which is still an interesting toy for the laboratory or study, but not fitted for general use. It furnished, however, an admirable illustration of the great principle of vibration, to which modern research points as the probable origin of all forms of force and motion.

The first chemical matches were often sold at from six to ten cents apiece. They were tipped with a mixture of chlorate of potash and sugar, or some other substance rich in carbon, and accompanied by a vial of sulphuric acid. When the match was dipped into the acid it took fire. Amorphous phosphorus was afterwards substituted for the acid, thus furnishing substantially the same combination that is used in the modern safety match. In 1829, John Walker, a chemist of Stockton-upon-Tees, dispensed with the bottle by including phosphorus in the mixture for the tips, and igniting the match by the friction of sand paper. This was the "lucifer" match, which interested Faraday so much that he sought to confer a great public benefit by promoting its introduction into general use. The various forms of friction match, with which we are all familiar, are merely modifications of Walker's lucifer. Coston's telegraphic night signals, which were in the Centennial Exhibition, are fired on the same principle.

A century ago, the oil lamp and the tallow dip, the latter being by far the more common of the two, helped to make darkness visible. In 1786, the Scottish lord, Dundonald, distilled coal and constructed an apparatus, merely as a curiosity, for burning the escaping gas. His canny workmen used the waste gas for light. In 1792, Murdoch began his attempts to introduce gas for lighting factories, but for several years his efforts met with little success. Westminster bridge was first lighted with gas in 1813, and the neighboring streets in 1814.

In 1790, there were but twenty-five post offices in the United States. Even so lately as in 1836, the postage on a single half-ounce letter was twenty-five cents for four hundred miles or over. Electricity was not impressed into the postal service, by Prof. Morse, until 1843. Prof. Henry's discoveries, which rendered practical telegraphy possible, began in 1830. The first efficient submarine link in Puck's "girdle round the earth," was laid in 1851, between Dover and Calais; the first Atlantic cable, in 1858. Now, through the judicious study of the effects of combined and superposed vibrations, we

have the duplex and quadruplex telegraph, and the telephones of Gray and Bell. There is good reason to believe that the telephones may be so perfected as to enable us, without limit of distance, to send an indefinite number of messages, at the same time and in opposite directions, over a single wire. Already, conversation has been carried on through a wire of over one hundred and fifty miles, so that the words were distinctly audible, and the voices of different speakers were readily recognized. Music has been transmitted from Chicago to Detroit, a distance of two hundred and eighty-four miles, the notes being as clear and distinct at the end as at the beginning of their telegraphic journey.

The granaries of the world are largely supplied by the crops of our teeming western prairies. The "staff of life" is cheapened by the improved drills, ploughs, cultivators, mowers, reapers and threshers, which enable our farmers to cultivate their immense fields and gather their bounteous harvests. The wooden plough, in the Tunisian department of the Exhibition, was nearly as efficient as the one which was used by our great-grandfathers; the present "header," for gathering clover seed, contains the only contrivance which they knew for rapid reaping. The header is, substantially, the same as the machine which was used by the Gauls, in the first century of the Christian era, having a comb in front to strip off the ears of wheat, and pushed by an ox. It received no material improvement until Ogle invented the reciprocating knife, in 1822. McCormick's reaper was not patented until 1834.

Our great-grandfathers rejoiced in leather aprons and homespun dresses. The hand-loom was a familiar household implement; the setting of hand cards enabled farmers' children to earn many an honest penny during the long, but cheerful, winter evenings that they spent in the chimney corner. Hargreaves patented his spinning jenny in 1770; Arkwright's contested patents, which enabled one man with a machine to do as much work as one hundred and thirty men could do by manual labor, were not sustained until 1785. It would require 40,000,000 laborers to do the spinning which is now done in England by machinery alone.

Samuel Slater, who was apprenticed at the age of 14 to Jedediah Strutt, Arkwright's partner, made such improvements that he was entrusted, before he came of age, with the supervision of a new mill and the construction of its machinery. Almy & Brown were then

about erecting a factory at Pawtucket, in which they offered Slater an interest. He accepted the offer, but the rigid British laws, against the emigration of artisans, prevented his taking any machinery or drawings with him. But his capacious head held all that he needed, and in 1790 he started the first successful cotton mill in the United States.

While constructing his machinery, Slater wished to obtain twilled cards of a pattern that had never been made in America. Pliny Earle, who agreed to make them, used two needles inserted in a bit of wood, to prick the holes in the leather into which the carding teeth were to be set. The tediousness of the operation led him to the invention of a machine which is still in use, and which, while it performed the work more satisfactorily, saved the labor of sixty men.

In order to prepare the cotton for carding, it was necessary to separate the fibre from the seed, a tedious process, especially with green seed cotton, which was the best variety. The cleaning of a single pound was considered a good day's work for a negro. This labor, added to the costs of cultivation, transportation, manufacture, reshipment, commissions and mercantile profits, made even the coarsest cotton goods expensive. Whitney's cotton gin, which was completed in 1793, raised the value of the cotton plantations, from fifty to one hundred per cent. Judge Johnson said, "If we should assert that the benefits of this invention exceed one hundred millions of dollars, we can prove the assertion by correct calculation." All the emolument Whitney received for this immense benefaction, was $50,000 from the state of South Carolina, a tax of two shillings and six pence levied for five years upon every saw used in North Carolina for ginning cotton, less the collection expenses, and some *promises*, which were never fulfilled, from other states. A large portion of the money which was thus obtained, the inventor was obliged to spend in vexatious lawsuits.

The increasing demand for machine cards, consequent on the reductions in the cost of cotton goods, stimulated mechanical ingenuity to devise means for their more rapid production. Eleazar Smith invented a machine which would pierce the leather, cut the wire, bend it into proper shape, or both bend and set it, provided the tooth was straight. But, in order to furnish the requisite resistance in the carding process, it was necessary that the tooth should be so bent as to form a knee; and after numerous vain attempts to set a bent

tooth, Smith abandoned his undertaking. Amos Whittemore had been experimenting in the same direction, and hearing of Smith's machine, he asked if he would sell it. A price being soon agreed upon, Whittemore took his purchase home, and the thought is said to have come to him, in a dream, that it would be just as well to bend the tooth after it was set, as to set it after it was bent. He accordingly added a simple bending die, took out a patent, and sold the right for $150,000. It was afterwards re-purchased by his brother Samuel.

The rapid increase in the production of plain fabrics, consequent upon these inventions, was accompanied by improvements no less wonderful in the weaving of ornamental designs. The warp threads were at first moved by treadles, the design being limited by the number of treadles that one man could work. "Draw-boys" were next introduced, who operated design cords which were fastened to the side of the loom; but the constrained position that they were obliged to keep, ruined their health in a few years. Vaucanson introduced tambour machines, which were subsequently improved and finally perfected by Joseph Marie Jacquard, who reduced the roller to eight sides, which carried an endless chain of cards, pierced with holes so arranged as to allow the passage, at the proper moments, of wires connected with the warp threads. The Lyons silk manufacturers wove a portrait of Jacquard in his workshop, which required 24,000 cards, each card being large enough to receive 1000 holes.

William H. Horstmann first introduced the Jacquard loom in America, in 1824. In 1837-8, his son, William J. Horstmann, manufactured power looms of his own designing, and employed them for weaving narrow textile fabrics. The complication, delicacy and accuracy with which the mechanical fingers and scissors and plyers of the card-setting and ornamental-weaving machines do their appointed work, entitle them to rank among the most wonderful triumphs of human skill and creative genius.

In order that the products of the loom may find a ready market, it is desirable that they shall be clean, and that their colors shall be "fast." Both of these ends are secured by the use of a very cheap soap, of which there are specimens on the table. You see that it is a very hard soap when in its most compact form, and that it looks very much like bottle glass. It is at once a glass, and a salt, and a soap, being the silicate of soda, or soluble glass. If it is allowed to run from the furnace into water, it crumbles into a coarse powder,

which can be dissolved in boiling water, forming a soapy solution, which may be used for washing, for taking the place of resin in common soap, for forming artificial stone, for fireproofing garments or scenery, for a mordant in fixing dyes, for lining coal oil barrels to prevent leakage, and for various other purposes.

Fibres may be felted, as well as woven. The true felting process, which you can see in any factory where wool hat-bodies are made, requires animal wool or hair. You may learn why the animal fibres tend to cling together, by working a hair lengthwise through your fingers. You can readily move it in one direction but not in the other. This is due to little protuberances on the surface of each hair, all pointing in one direction, and the interlocking of those protuberances gives considerable strength to the bocking or other felted product.

Paper is a sort of felt, but the adhesion of its fibres is mainly due to a kind of paste. The "mammoth ream," with material sufficient for 500,000 sheets of note paper, and the general American display of paper, in all the principal styles of manufacture, attracted great attention from the foreign visitors to the Exhibition. The parchment papers, suited for bookbinding—the paper imitations of silk and leather, for hangings and other purposes—the great variety of applications of papier-mâché and carton-pierre, the "matrix" for stereotyping any required number of duplicate forms to be used in printing newspapers—represent only a few of the late inventions in this single line of manufacturing industries. By means of the continuous rolls, the cutters, the cylinders, the flexible matrices, and the webs, the clumsy and tedious processes of forty years ago have given place to fast presses that are capable of printing a mile of newspapers per minute, throwing off the printed and folded sheets as fast as two active boys can carry them away.

Those of you who have read Gulliver's travels, will remember that the philosophers of Laputa were represented as engaged in endeavors to extract sunbeams from cucumbers. Can you imagine any idea more absurd? Can you not picture to yourselves the smile of satisfaction that lighted Swift's face, as he penned the keen sarcasm on the philosophical speculations of his day? Yet in science, as in religion, we may often apply the maxim, "*credo quia impossibile est*"—its very impossibility makes it credible. The Laputan dream has been literally fulfilled; for if you gather a cucumber that has been

exposed to the strong sunlight, take it into a dark room, wrap it in paper that has been prepared for photography, and shield it in all possible ways from external light, the delicate vibrations which have been absorbed will again be given forth, imprinting a distinct image of the cucumber on its sensitive wrapper. In connection with this fact it may be well to remind you that, although Davy and Niepce had developed camera pictures, and Daguerre had made them permanent, the limning sun took its first portraits in America.

Such are a few of the inventions which have contributed to the marvelous physical progress of the past century. From the many others I will select but one; the one which is, in many respects, the most important of all: the steam engine. Hero, of Alexandria, invented the eolipyle, which remained, for ages, an unsuggestive toy; the Marquis of Worcester described forms of apparatus by which steam could be applied to useful work; Savary, Newcomen and Crawley made pumping engines for the drainage of wells and mines; but it was left for the ingenuity of Watt, by a series of improvements which were completed in the year of our national birth, to give us that mighty instrument of unwearying and unlimited toil which has wrought a revolution in our homes, in our workshops, on our farms, on our highways, in the bowels of the earth, and on the face of the mighty deep. Steam was first applied to cotton machinery by Arkwright, in 1785; to sawing stone and grinding plaster, by Oliver Evans, in Philadelphia, about the same time; to a boat on the Forth and Clyde canal, by Symington, in 1802; to river navigation, by Fitch, Stevens, Evans and Fulton, between 1804 and 1807; to a road engine or locomotive, in 1805. Stephenson's "Rocket" first drew a train of cars at the opening of the Liverpool and Manchester Railway, in 1829. The first century of this mighty monarch's sway has ended, and through its instrumentality the capacities of mechanical industry have been increased more than tenfold. Machinery is now doing more work than the whole population of the globe. The beautiful engine in Machinery Hall, which accomplished, so easily and so quietly, a task such as had never before been witnessed, may therefore be fitly remembered as the centre of our exhibition, which worthily and suggestively exemplified "the inventions of the century."

[The lecture was copiously illustrated by experiments, specimens of materials and fabrics, and lantern pictures.]

THE METALLURGY AND ASSAYING OF THE PRECIOUS METALS USED IN COINAGE.[1]

[Abstract of the first of a course of two lectures, delivered before the members of the Franklin Institute.]

By ALEXANDER E. OUTERBRIDGE, JR., Assay Department, U. S. Mint, Philadelphia.

ON GOLD.

The book of nature is a vast volume, from any part of which we may obtain wonderful sources of instruction and entertainment. Whether we contemplate the immensity of the vault of heaven with its innumerable suns revolving in their orbits, or whether we examine the tiniest blade of grass or the sting of the smallest bee, we find equally interesting subjects for study. It is one chapter, nay, rather one small page, of this great book, which I propose to open for you this evening, and my subject possesses one material advantage in its novelty in a lecture course.

The history of the precious metal which we call gold, carries us far back to the first records of the civilization of the human race. There is every probability that gold was the first metal known to man. Centuries before its use as a medium of exchange or unit of value, it was known and highly prized as an article of ornament. The ancient symbol of gold among the Egyptians was a circle, which typified to their minds the idea of perfection and divinity.

In the Old Testament we find very frequent mention of gold, and the vast amounts of precious metal used by King Solomon in the adornment of the Royal Palace and the Holy Temple excite our wonder and admiration.

The marvelous accounts related by the classic writers of the great quantities of gold possessed by the Oriental monarchs of antiquity must, of course, in some cases be accepted *cum grano salis*, and yet the recent archæological and treasure discoveries of General Di-Cessnola, in Cyprus, and of Dr. Schliemann at Mycenæ, are at

[1] As the lectures were not delivered from manuscript, this abstract for the JOURNAL has been prepared from memory, assisted by brief notes of headings. It has been found necessary, on account of limited space, to omit some portions, and to curtail others.

least partial confirmations of the stories related by Herodotus, Pliny, Homer, and other ancient authors. The beautiful collection of Etruscan and Phœnician golden ornaments—amulets, rings, fibulæ, etc., exhibited in the Castellani collection at the Centennial Exhibition, is a proof of the antiquity of the art of refining gold and working it into artistic forms of great beauty. Indeed the method of joining microscopical particles of gold, forming the ornamentation called "granulated work," is a marvel to modern experts.

I wish you to pause with me for a moment to consider a phase in the history of the precious metals of absorbing interest—I allude to the search for that ever fleeting will-o-the-wisp, the Philosopher's stone. Although we may laugh at the delusions under which the enthusiastic alchemists of the middle ages labored in their search for that *elixir-vitæ* which was to enable them to cure all ills, to prolong life to an indefinite period, and to transmute the precious metals into gold, we must not forget that we owe to their labors many valuable metallurgical discoveries. The older alchemists believed that the great secret was possessed by the Devil and could only be procured at the expense of the soul—while the more modern enthusiasts relied upon earthly means, and they accordingly triturated and boiled together the most heterogeneous compounds. Thus, in an old work, called the "Gold maker's guide," there appears this amusing recipe: "Take of the gall of a black tomcat, killed when the night approacheth, 1 part; of the brains of a night owl taken from out its head when the morning dawneth, 5 parts; mix in the hoof of an ass when the tide turneth; leave it until it doth breed maggots; place it on thy breast-bone when the moon shineth bright—and—thou wilt see a sight which the eye of mortal man ne'er beheld afore." Again, "Hide and couple in a transparent denne, the Eagle and the Lyon, shut the doore close, so that their breath go not out, and strange ayre enter not in; at their meeting the eagle will tear in pieces and devoure the lyon and then be taken with a long sleepe." The explanation of such riddles is simple enough when we have the key; for example, I have in my hand a glass vessel containing gold foil; this is typified by "the lion." I now cast in "the eagle," viz.: a little mercury; the mercury quickly forms an amalgam with the gold and becomes a sluggish or pasty mass, *i. e.* "is taken with a long sleepe."

Numerous guides appeared from time to time, but, unfortunately, those which were written plainly never yielded a stone, while those

written enigmatically could not be understood.[i] This mysterious manner was not always owing to an intention to deceive—many philosophers believed it was wicked to reveal the secrets of nature to the vulgar people, and might even cause the death of the writer.[ii] So strong was the faith in the power of transmuting base metals into gold, that Henry VI of England issued a royal proclamation, in the year 1423, encouraging the art of gold making, in order to obtain means to pay the state debt. Edward IV, in 1476, accorded to a company "a four yeare privilege of making gold from quicksilver.[iii]

Our limited time will merely permit us to glance at these interesting by-paths in the history of the precious metals, and we are now prepared to investigate the

PHYSICAL AND CHEMICAL PROPERTIES OF GOLD.

You are all, doubtless, familiar with the rich orange-yellow color of gold, and yet but few of you have seen the royal metal in a state of purity. In this little porcelain saucer I have fastened with mucilage a number of granulations of chemically-pure gold. This gold is prepared with the most scrupulous care in the Assay Laboratory of the Mint, for test purposes, and is absolutely free from foreign substances.

By the aid of the improved form of megascope, devised by the Secretary of the Institute, Mr. J. B. Knight, I shall project the magnified image of these beautiful granules upon the screen. There, you see, they retain their natural brilliant lustre, golden color and

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[i] In 1649 there appeared, "A master key to the opened heart of fatherly philosophy, and the "Childbed of the philosopher's stone."

In 1700, "Philosophical field sports and nymph catching," and the "Brightly shining sun in the alchemical firmament of the German horizon," "Chymical moonshine," etc., etc.

[ii] Wilhelm von Schrœder, in 1684, wrote a book called "Necessary Instructions in the Art of Gold Making," in which he says: "When philosophers speak openly, a deceit lies behind their words; while when they speak enigmatically, they may be depended upon."

[iii] The Danish ducats of 1647 were made of gold obtained, as it was believed, from artificial means, by the alchemist of Christian IV, named Caspar Harbach. So under the Emperor Ferdinand III, in 1648, a large medal was struck from artificially-prepared gold. In like manner the ducats struck under Landgrave Ernest Lewis, of Hesse Darmstadt, were of artificial gold, prepared, it was said, by the transmutation of lead.—*Reducer's Manual.*

appearance of solidity.[1] So much for the color of gold by reflected light. Here is a sheet of gold-leaf, mounted on glass; it is partially transparent, and you might suppose that the transmitted light would also have the same orange-yellow color; let us see. I place the leaf in the oxy-hydrogen lantern, and the disc of light upon the screen is tinged a decided *bluish green.* This property of reflecting one color and transmitting another, is peculiar to gold. We are thus led, by a natural association of ideas, to the question, how thin is this sheet of gold-leaf?

The wonderful malleability and ductility of gold was a property well known to the ancients. Homer speaks of the art of gold beating, and Pliny mentions that an ounce of gold was beaten into 750 leaves, each leaf being about four fingers square. Gold leaves of extraordinary thinness have been found on the coffins of the Theban mummies. The rude specimens of gilding on the walls of the Peruvian temples, and the palace of Tippo-Sahib at Bungalore, prove its extensive application in ancient times. We also have biblical authority to the same effect.

Experiments made in modern times have shown that a grain of gold can be beaten out so as to cover a space of 75 square inches, having a thickness or rather thinness of $\frac{1}{367650}$ part of an inch. While reflecting upon this remarkable fact, the thought suggested itself to me, that the film of metallic gold deposited by means of the galvanic battery must be far thinner. And as the art of gold plating is so extensively applied to a great variety of ornamental metal objects, it seemed an interesting query, how thick a film is required to produce a fine gold color? On inquiring into the subject I did not find that any careful notes had been recorded, and I was led to try some experiments with rather interesting results, although they are not yet finished. Here are two highly burnished plates of metal, looking like pure gold; they have a metallic surface of twenty square inches each; these plates were cut from a strip of copper which I had rolled down to a uniform thickness of $\frac{5}{1000}$ of an inch. They were boiled in alkali to remove grease, and accurately weighed on an assay balance of extreme sensitiveness.

A "gold blush" of sufficient depth to produce this fine gold color was then deposited by the battery; the strips were carefully washed

[1] Several gold coins, medals and ornaments were exhibited, and elicited the applause of the audience, both on account of their inherent beauty and the brilliancy of their reflection.

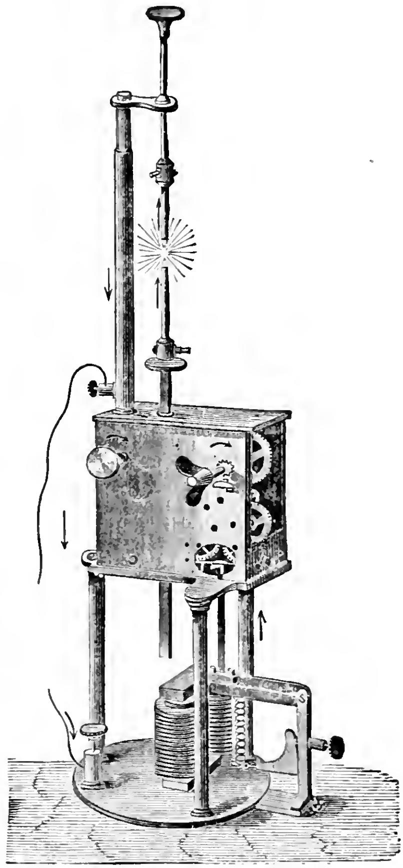
and dried without rubbing; they were then reweighed, and I found they had gained exactly one-tenth of a grain each. It is thus apparent that one grain of gold would cover a space of 200 square inches, when deposited by the battery, as compared with 75 square inches by beating.

The film of gold appears evenly deposited, under the microscope, and it is more than $2\frac{1}{2}$ times thinner in the former case than in the latter, or $\frac{1}{980400}$ of an inch as compared with $\frac{1}{367650}$ of an inch.[1]

It is stated, that when a cylindrical bar of silver is coated with gold and drawn into the fine wire used in embroidering housings, etc., one grain of gold will cover a length of 345·6 feet of wire.

Gold deserves its name of "noble metal" from its power of resisting the rusting and tarnishing action of the atmosphere, even when subjected to the severest trials. Kunckel kept a mass of gold in a molten state exposed to the atmosphere, for a period of nearly 30 weeks; at the end of that time it had not lost a single grain in weight.

Gold may be melted at a temperature of a little over 2000° F. in a wind furnace.



Electric Lamp.

We may even cause gold to boil and vaporize by means of the intense heat of the electric arc. Here is an apparatus designed to produce an exceedingly powerful electric current. The copper wires

[1] "A leaf of beaten gold occupies an average thickness of no more than one-fifth to one-eighth part of a single wave of light. By reducing the thickness of the leaf by solution in cyanide of potassium, I think 50 or even 100 might be included in a single progressive undulation of light."—Faraday's Researches on the "Experimental Relations of Gold (and other metals) to Light."—*Philos. Trans.*

conveying the current terminate in two sticks of carbon placed vertically one above the other in the focus of the condensing lens of this large lantern; when the points of carbon are brought in contact they become intensely hot, and on separating the poles, the current is carried across the hiatus, by the conductivity of the carbon particles. The lens projects the greatly magnified image of these incandescent poles upon the screen.[i] In the lower carbon is bored a small cavity into which I place a particle of gold, and you see its image just appearing upon the screen as a globule becoming white hot; ah! now it boils, and there darts forth an exquisitely beautiful tongue-like flame of *vapor of gold*, licking the carbon points, and there, upon the opposite electrode, are rapidly appearing small brightly shining beads of condensed vapor of gold, resembling sparkling dewdrops.[ii]

Carbon Points.

Gold resists the solvent action of nearly all single acids, but a mixture of nitric and muriatic completely dissolves it as a perchloride; hence the alchemists gave the name of *aqua-regia* to this combination. Here are three glass vessels containing sulphuric, nitric and muriatic acids, with a piece of pure gold in each one, where it has remained for several hours, quite unchanged. I now pour the contents of the last mentioned vessels together, and our gold dissolves almost immediately.

Having in this manner obtained a solution of gold, we are prepared to test it with several characteristic re-agents. I place a few drops of the gold solution in this little tank containing distilled water, which you see reflected upon the screen; I now add a single drop of the solution of proto-sulphate of iron, and instantly a dark precipitate of metallic gold in fine division, rolls like angry thunder clouds over the canvas. This method of precipitation is used in the mint in the preparation of chemically-pure gold. I now add, to a fresh solution of gold, a drop of ammonia: a precipitate of

[i] The cut shows the carbon points inverted, as they appeared on the screen.

[ii] The apparatus used for the development of the electric current was "Wallace's Duplex magneto-electric machine," and was kindly furnished for these lectures by the manufacturers, Messrs. Wallace & Sons of Ansonia, Conn. The shaft was revolved at about 1200 revolutions per minute by a steam engine placed at the back of the stage. The light produced was remarkably steady and intensely brilliant.

a very different character appears upon the screen. This is the substance known as *fulminating gold*, and is a dangerously explosive compound; fatal accidents have occured from its careless or ignorant preparation. Again, I take a fresh solution which is somewhat acid; into the tank, I place a thin strip of tin, it is attacked by the acid; proto-chloride of tin is formed, which instantly unites with the gold, developing very pretty purple streamlets. This is the well known "purple of Cassius," about whose chemical composition there has been a great deal of discussion. The Cassius purple is largely used in the arts, in staining ruby glass, and giving to enamel the delicate rose-pink color.

SOURCES OF GOLD.

To say that gold is at once a *rare* metal, and yet that it is one of the most widely disseminated of the metallic elements, seems at first sight contradictory; and yet it is, in a sense, literally true. Gold is found in Europe, Asia, Africa and America; it was known, in the time of Herodotus, to exist in Russia in the Ural Mountains. The mines were afterwards re-discovered in 1743, during explorations ordered by Peter the Great. The gold and silver mines of Spain have been worked from the most remote periods; both Strabo and Pliny mention the abundance of the precious metals, and it is stated that Hannibal would have been unable to continue the war in Italy but for the discovery of many mines in Carthagena. China and Japan, India, Ceylon, Sumatra, Borneo, the Celebes and Philippine Islands, all add a sheaf to the golden harvest. The mountains and streams of Africa all contain gold. The Transvaal Republic, in Southern Africa, promises vast wealth of native gold to the hardy explorer; some magnificent nuggets were brought to us recently by a prospector from this almost inaccessible region. Some of these nuggets were for a short time placed at the Centennial Exhibition.[1]

It remains for our own country to have the honor of possessing the most extensive gold and silver producing regions of the world at the present day. California and Oregon, Idaho and Washington territories, Nevada and Colorado, Montana, Arizona and New Mex-

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[1] A *fac-simile* of one of the largest nuggets ever found in Australia was exhibited to the audience. It was prepared at the Department of mines in Melbourne, and formed an attractive object in the Victorian Court of the late exhibition.

ico, all contribute their quota.[i] Even the Philadelphia bricks, of which our houses are built, contain gold securely locked within their walls, as was proved by the interesting investigations made in the mint some years since.[ii] Here is a speck of gold, barely visible to the naked eye, which was extracted at the assay laboratory from galena of Bucks Co., Pa., representing one part of gold in 6,220,000 parts of ore.

GEOLOGICAL POSITION.

Gold is found in nature in the form of dust, grains, nuggets, and associated with quartz, etc. "It was formerly supposed that productive gold veins were confined to the Silurian rocks, but the discovery of fossils of the Carboniferous period in California by Dr. Trask in 1854, the exploration of Professor Blake, and the subsequent discovery of secondary fossils in the main belt of gold bearing States, together with the discoveries in Hungary in 1861–62, proving that the rocks holding the gold belong to the latest geological periods, even as late as the Tertiary—all show the fallacy of the opinion that productive gold veins are associated chiefly with the older rocks."[iii]

MINTING.

Gold is received at the mint in the form of native grains, dust, amalgam, photographers' waste, old jewelry, dentists' plate, etc., and often contains a great variety of base metals, destroying its ductility, and rendering it totally unfit for coin. It is necessary to eliminate these, and then to effect the removal of silver. We will follow in imagination the course of a deposit, consisting, let us suppose, of old coin and jewelry, as it is received at the mint counter.

The metal is placed in a locked box, and carried to the "deposit

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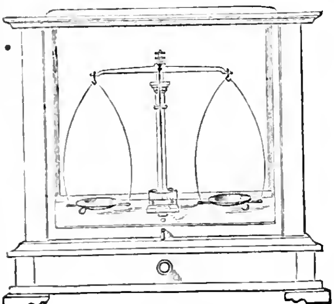
[i] According to the record of Wells, Fargo & Co., the sole carriers of the gold and silver product of the Pacific States, the total gold product of the mines west of the Missouri River, for the year 1876, was $44,828,501. This exceeds the amount produced in any year since 1870. The highest yearly product was $65,000,000 in 1853. The total gold produced since 1849 is $1,858,400,745. The total stock of gold in the world, at the present time, has been estimated at $5,540,000,000, with an annual loss by wear and tear of $15,000,000. This is interesting, but can hardly be considered more reliable than a guess.

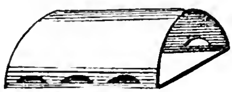
[ii] The report of these experiments, made by Profs. Eckfeldt and DuBois, states that the clay contains about forty cents' worth to the ton; that it is homogeneously diffused; and, from an estimate made of the extent of the clay bed, it was found that more gold lies under the paved portion of the city "than has yet been brought, according to the statistics, from California and Australia."

[iii] Blake's Report on the Precious Metals at the Paris Exposition.

melting room;" here it is melted under a protective covering of borax, and constantly stirred, to render the mass homogeneous. It is then cast into a bar or "shoe" mould, and weighed; this is the weight at which the mint receives the deposit. A small chip is now cut off, for purposes of assay. A rigid analysis is made of this sample, and the result determines the value of the entire mass, by calculation to the fraction of a cent, and the depositor is paid accordingly. As the largest weight used by the assayer is the demigramme (about $7\frac{7}{10}$ grains Troy), and the deposit frequently represents thousands of dollars, it is evident that a very slight error in the assay would amount to a considerable sum total;[1] the assayer accordingly carries his actual analysis to the ten-thousandth degree, viz.: the twentieth part of a milligramme, or the $\frac{1}{1295}$ part of a Troy grain. The fine assay balances will indicate even a smaller weight than this. The assayer rolls the sample into a thin ribbon, for convenience of cutting; the weight of half a gramme of this gold alloy is enclosed in an envelope of pure lead, and melted in the muffle of the assay furnace, in a small cupel made of pressed calcined bones. The lead rapidly oxidizes, and in this condition is much more fluid than the simply melted precious metal; it therefore sinks into the pores of the cupel, carrying with it all the base metals originally combined in the alloy; the button of precious metal remaining is weighed, and the proportion of base metal determined; another weighing of the sample is made as before, to which is added fine silver granulations in the proportion of about two parts of silver to one of gold. The alloy is cupelled as before, and the silvery button remaining is laminated, coiled into a "cornet," and boiled in nitric acid. The acid dissolves all the silver, leaving a roll of pure



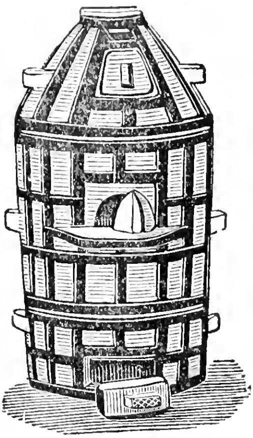
Assay Balance.



Muffle.

[1] The average weight of one "melt" of gold ingots for coin, the fineness of which is determined by assaying a slip cut from the first and last ingot cast, is 4000 ounces Troy. The value is about $75,000 in gold. Melts containing as much as 5500 ounces have been made, but it is found very difficult to render the metal homogeneous, owing to the difficulty of pushing the stirrer down to the bottom of the pot.

gold remaining; the gold cornet is then annealed and weighed; this weight is the proportion of gold; the difference between this and the first weight, is the proportion of silver.[i] The object of adding pure silver to the alloy is, in order that it may be present in excess; otherwise the atoms of gold cover up and protect the silver originally present in the alloy.



Assay Furnace.

Numerous checks are employed to correct variations, and so accurate are these devices that two samples taken from the bar will frequently be found, after passing through the various chemical and mechanical operations of hammering and rolling, melting, fluxing and dissolving (providing the original melting rendered the mass homogeneous), to show a deviation in the assay of not more than one-thousandth part of a single grain. The methods of refining gold adopted in the mints are so closely associated with silver, that the two will be incorporated in the abstract of the second lecture.[ii]

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[i] Strictly speaking, the gold cornet is not absolutely pure, but contains a small "sur-charge" of silver. The weight of the sur-charge varies according to the temperature of the furnace and other causes. This slight but important variation is determined by means of "proof assays" of chemically-pure gold, which are invariably made side by side with the others, and the proper correction is made for each. The boiling in nitric acid was formerly effected in separate glass flasks, but a great improvement has been made, in comparatively recent years, whereby the cornets are all subjected to the same acid and the same heat. A small platinum basket, perforated with holes, is made to contain a set of sixteen platinum thimbles. One cornet is placed in each, and the basket is immersed in nitric acid contained in a small platinum still. The boiling is effected by a Bunsen burner. When the silver is dissolved, the cornets are washed, dried and annealed in the basket. It is necessary to know, approximately, the amount of silver originally in the alloy; otherwise, if too great an excess is added, one of the cornets may break up, and, becoming diffused through the acid, small particles will attach themselves to the other assays and ruin the whole set. This is a misfortune that rarely happens to a careful assayer.

[ii] Through the courtesy of the chief assayer, the lecturer was enabled to illustrate his descriptions by the aid of apparatus in daily use in the mint. *Fac-similes* of gold bars, ingots for coin, native grains and nuggets, were shown, prepared in plaster of Paris, and covered with gold-leaf. Large oil paintings, showing the geological structure of the gold regions of California, and the methods of washing, were kindly lent by Professor Booth.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. CIII. MAY, 1877. No. 5.

EDITORIAL.

NOTICE.—The publication of the JOURNAL is made under the direction of the Committee on Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Franklin Institute.

HALL OF THE INSTITUTE, April 18th, 1877.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 163 members and 5 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers and reported that at its last meeting 14 persons were elected members of the Institute, and that the Board in compliance with a petition, signed by twenty-five members, has authorized the organization of a Phonetic Shorthand Section of the Institute.

The Actuary also reported the following donations to the library:

The art of projecting, by A. E. Dolbear. Boston, 1877. From J. B. Lippincott & Co.

Pennsylvania archives, 2d ser., by J. B. Lynn and W. H. Egle, M. D. Vol. 2. Harrisburg, 1876. From the Historical Society of Pennsylvania, Philadelphia.

Map of the Middle British Colonies in North America, by T. Pownall, 1876. Map sur la navigation de Terre-Neuve à New York. (Brought to America by Benj. Franklin, 1785.) From T. Hewson Bache.

Catalogue of physical instruments made by N. H. Edgerton, Philadelphia.. From the maker.

Report of a reconnaissance from Carroll, Montana Territory, to the Yellowstone National Park and Return, by Wm. Ludlow, 1875. Washington, 1876. From A. A. Humphries, chief of engineers.

The Road: Vols. 1 & 2 in 1 vol. Philad'a, 1877. From T. S. Fernon, Philad'a.

Translated memoir upon the illumination and beaconage of the coast of France, by M. Léonce Regnaud. Wash., 1876. From the Lighthouse Board.

Astronomical and meteorological observations, made during 1874, at U. S. Naval Observatory. Wash., 1877. From the Navy Dep't, Washington.

Annual report of the Lighthouse Board, for 1876. From the Board.

Minutes of proceedings of the Institution of civil engineers; Vol. 47. Session 1876–77, Pt. 1. From the Institution, London.

Twenty fifth annual report of the board of water commissioners to Common Council of the city of Detroit, etc., for 1876. From D. F. Henry, Chf. Eng.

Annual report of the geological survey of New Jersey, for 1876. Trenton, 1876. Fourth annual report of the New Jersey State board of agriculture, for 1876. Trenton, 1877. From G. H. Cook, Secretary.

Comptes rendus de l'Académie des Sciences, Paris. 6 numbers, 3 indexes and 6 vols. From the Academy.

Annals of the astronomical observatory of Harvard College. Vol. 6–8, 1859–76. From the College.

Speculation concerning molecular physics, by A. J. Stevens. Cambridge, 1877. From the author.

Phonetic Journal, for 1 year, from January 1877. From D. S. Holman.

Illustrated and descriptive catalogue of Locks, Knobs, etc., etc., manufactured by Mallory, Wheeler & Co. Fo. Conn. 1871. From Truman & Shaw.

Annual report of the Committee of management to the members of the Manchester Steam Users' Association. From the Assn.

Annual report of the Chief Signal officer to the Secretary of War, for 1876. From A. J. Myer, Chf. Signal officer.

The Actuary further reported the following Standing Committees of the Board for the current year, as appointed by the President:

(1) *On Instruction.*

J. B. Knight,
Theo. D. Rand,
Pliny E. Chase,
Samuel Sartain,
Washington Jones.

(2) *Elections and Resignations.*

Henry Cartwright,
William Helme,
Charles S. Close,
Cyrus Chambers, Jr.

(3) *Stocks and Finances.*

William Sellers,
Frederick Fraley,
J. Vaughan Merrick,
Enoch Lewis,
William P. Tatham.

(4) *Publications.*

Charles Bullock,
Samuel Sartain,
Joseph M. Wilson,
Pliny E. Chase,
Theo. D. Rand.

(5) *Exhibitions.*

William P. Tatham,
Chas. S. Close,
Coleman Sellers,
J. E. Mitchell,
Frederick Fraley.

(6) *Sections.*

Dr. Isaac Norris, Jr.,
Cyrus Chambers, Jr.,
Henry W. Bartol,
Hector Orr,
C. H. Banes.

The Secretary reported from the Committee on Science and the Arts that at its last meeting it recommended to the Board of Managers the award of the Elliott Cresson Gold Medal to Mr. P. H. Dudley for his Dynograph for measuring railway resistances.

The papers announced for the evening were then read by their respective authors, as follows: one on the manufacture and culture of Flax, by Mr. Hector Orr, and one on the Natural Sciences in Common Schools, by Prof. J. Ennis.

The Secretary presented his report, embracing the following subjects: An illustrated description of the steam street car, built by the Baldwin Locomotive Works, accompanied with an account of its performance during four weeks that it has run on the Market Street line, with amount of coal consumed and other items of cost of running; Mr. Theodore Bergner's Drawing Board, which is provided with a more perfect device than the T square for drawing parallel lines, and not depending on the edges of the board for its accuracy; Mr. N. H. Edgerton's improved projecting lantern and attachments; Mr. E. Strangland's apparatus for steaming grain and vegetables for food for domestic animals; and a new method of folding paper devised by Mr. J. W. Nystrom.

Under the head of deferred business the resolutions of Mr. J. J. Weaver, offered at the last meeting, relative to keeping a list of members out of and desiring employment, were taken up.

Mr. H. Cartwright offered the following as a substitute for both the resolutions of Mr. Weaver:

Resolved, That the Secretary be directed to provide a book in which shall be entered the names, occupations, addresses and references of those members of the Franklin Institute who may report to him as desiring employment, or those needing services of others, which book shall always be open for inspection by members of the Institute; and that all members of the Institute be notified of this arrangement.

On motion, the substitute was adopted.

A letter to the President of the Institute was read from L. M. Haupt, setting forth the advantage to be derived from the continuation of the triangulation of Pennsylvania, as provided for in the Act of Congress approved March 3d, 1871, and requesting the co-operation of the Institute in efforts to procure an appropriation for that purpose by Congress, at the extra session to be convened in June next.

On motion, the officers of the Institute were directed to sign the following memorial:

FRANKLIN INSTITUTE, PHILA., APRIL 18TH, 1877.

Hon. C. P. PATTERSON, Superintendent U. S. Coast Survey,

Sir:—We have learned with regret that the last Congress adjourned without making an appropriation for the continuance of the Triangulation of Pennsylvania.

As such a survey is the basis of all correct information concerning our lines of communication, internal improvements, geological structure, geodetic positions, and, in short, of our general welfare, we have the honor respectfully to request you to urge upon the Congress to be convened in extra session, June 4th next, the importance of supplying the omission by making such an appropriation as will enable the work to be continued through the year.

On motion of Prof. Haupt, it was

Resolved, That it is the desire of the Franklin Institute that the appropriation (requested in the accompanying memorial for the geodetic survey of Pennsylvania) should be made by the extra session of Congress to be convened in June next.

A report was presented from the Phonetic Shorthand Section, showing that, under the authority given by the Board of Managers, the petitioners met on the 13th inst. and organized by electing the following officers: President, E. Alexander Scott; 1st Vice-President, D. S. Holman; 2d Vice-President, M. F. Lobo; Recording Secretary, John Haug; Corresponding Secretary, Franklin E. Page; Treasurer, Jas. A. Kirkpatrick; Conservator, Danl. Carhart; that a committee was appointed to prepare by-laws for the government of the section, and that the necessary qualification for membership in the section is the ability to read phonography in accordance with Pittman's system. The section will meet on the fourth Wednesday of each month.

On motion, the meeting adjourned.

J. B. Knight, *Secretary.*

Planing, Slotting and Shaping Machine.—Messrs. Wm. Sellers & Co. have recently completed, after nearly two years' work, an immense machine combining in one all the movements of planing, slotting and shaping machines. It is arranged with a stroke of 24 ft. when used as a planer, with a stroke of 12 ft. as a slotter, and of 6 ft. as a shaping machine. The motion of the machine in each of its capacities, is independent of the other motions, and is provided with independent hand and automatic feeds in all directions, and automatic stop. All these are controlled by the workman, who is carried on a platform within easy reach of the cutting tool.

The machine was designed to supply a means of dressing work too large to go on ordinary planing machines, such as bed-plates for marine engines, and other large machinery, and differs from other machines designed for the same purpose, in combining with the horizontal and vertical movement in one plane, a horizontal one of 6 ft. at a right angle to the first.

The work to be planed, which may be of any size, is secured to heavy foundation plates alongside of the machine, and remains stationary, and such portions, within a space of 24 ft. by 6 ft. horizontal and 12 ft. high, as require it, can be dressed.

This machine was built to fill an order from the Russian Government, and is to be placed in the navy yard at Cronstadt. An illustration of the machine, with a detailed description, will probably be given hereafter.

K.

Continuous Brakes for Railroad Trains.—The great value of continuous brakes for railroad trains has long been appreciated in this country, and scarcely one of our great lines can be found without them on all their passenger trains.

It is only recently, however, that this subject has received the attention it deserves in England, but when once awakened to it the railroad managers with characteristic thoroughness determined to know which is the best, and recently have had two well known systems subjected to a series of tests, the results of which are of the first importance as relating to rapid passenger traffic.

The two systems most favorably known in England, were the Westinghouse Automatic Brake (which was first thoroughly tested and reported upon by the Committee on Science and the Arts of the Franklin Institute on May 20th, 1873,[1] and awarded the Scott Legacy Premium and Medal), and the Smith Vacuum Brake—both American inventions. The former of these had been attached to the more important trains on the Midland Railway, and had already done good service in mitigating the effects of one accident and of preventing another, and the latter had been experimented with to some extent by the Great Northern Railway.

With the view of determining by a thorough test in actual practice which of the two was the better, Mr. D. Dunmore, Locomotive Superintendent of the North British Railway, gave to the representatives of the Westinghouse and Smith brakes, each a train of cars, to be equipped in the most complete manner, to be used in a series of experiments, and in daily work, to settle the question of superiority.

Mr. Dunmore called to his assistance, as a committee to aid in making the tests, the following gentlemen, representing large interests: Mr. Wm. Cowan, Locomotive Sup't of the Great North of Scotland Railway; Mr. Barton Wright, Locomotive Sup't of the Lancaster and Yorkshire Railway; Mr. Haswell, Chief Ass't Locomotive Engineer of the North Eastern Railway, and Mr. Sterling, Local Sup't of the Glasgow and South Western Railway.

The train fitted with the Smith vacuum brake, consisted of a four-wheeled coupled inside cylinder engine, with a two-wheeled Adams bogie under the leading end, and weighing 36 tons, tender weighing $20\frac{1}{2}$ tons; eight carriages, two vans with pumps to assist brakes, and

[1] See Vol. 67—3d Series, page 237.

TABLE SHOWING THE RELATIVE EFFICIENCIES OF WESTINGHOUSE AUTOMATIC AND SMITH VACUUM BRAKES, AT INTERVALS OF 100 FT., FROM MOMENT OF APPLICATION TO STOPPING TRAIN.

Number of Stop.	Train speed in miles per hour when brake was applied.	Train Speeds after Brake has been applied over the following distances.													Total Distance Run.	Time.	—	Remarks.
		100 feet.	200 ft.	300 ft.	400 ft.	500 ft.	600 ft.	700 ft.	800 ft.	900 ft.	1000 ft.	1100 ft.	1200 ft.	1300 ft.	ft.	sec.		
7	40 +	40 −	38¼	37½	34	30	25½	18	......	......	......	......	......	......	800	22½	Smith Vacuum. Glasgow to Edinburgh.	
8	41½	41	43	41½	39	36¼	32	28	22½	12½	......	......	......	......	950	24		
9	45	44¾	44¼	43	41½	38½	35½	31¾	27	21½	11	......	......	......	1020	25½		
10	49½	49¼	49	48	46¼	43½	41¼	38	34	29¾	24	16	......	......	1170	27¼		
11	46½	46¼	45½	41	42	39¾	37	33	28	22½	14½		......	......	1050	26		
13	49	48¾	48¼	47½	46¼	43¼	40¾	37½	33¼	28¼	22½	12½	......	......	1138	26½		
2	29½	29½−	27½	23¼	17½	......	......	......	......	......	......	......	......	......	480	17¼	Smith Vacuum. Edinburgh to Glasgow.	
5	40	39¾	38¼	36	32½	27½	22	15	......	......	......	......	......	......	740	20¼		
6	40	39¾	39½	38¼	36¼	32½	28	22½	16¼	......	......	......	......	......	860	23	....	Diagram shows application of brakes before indicator was started.
7	49½	49¼	49	48¼	47	44	42	38¾	35	30	25	18	......	......	1175	26		
9	49½+	49¼	48¾	48	46¾	41¼	42¼	38½	35	31	26	20	......	......	1195	27		
11	55 −	54¾	54	53	52	50	47½	45	42	38¼	35	30½	25	17½	1375	28		
12	51	53¾	53¼	52¼	51¼	48½	46¼	43	39¾	36¼	32	26¼	18¾	8	1310	28		
13	40½	40½−	39¾	38	36	32	27	21½	12	......	......	......	......	......	830	23		
14	40	39¾	39	38	35	31¼	26½	20½	10	......	......	......	......	......	810	22½		
15	49½+	49½	49¼	48¾	48	46¾	44¾	42	38½	35	30½	24	15½	......	1250	27	....	Not as promptly put in action as compared with the other stops.
2	30	29	21	16½	......	......	......	......	......	......	......	......	......	......	350	13	Westinghouse Automatic. ... Glasgow ... to Edinburgh.	
3	30 +	28¼	22	13	......	......	......	......	......	......	......	......	......	......	328	13		
4	40	39¾	37	33	25¾	16½	......	......	......	......	......	......	......	......	550	16		
5	40 +	39¾	36¼	31¼	25½	17	......	......	......	......	......	......	......	......	550	16		
6	49¾	49½	47½	43½	40	35	28½	21	......	......	......	......	......	......	798	19		
7	50 −	49¾	48	43¼	38	33½	27½	20	......	......	......	......	......	......	777	18¾		
8	31	29¾	23½	16	......	......	......	......	......	......	......	......	......	......	345	12¾		
9	30	30	26½	20	7	......	......	......	......	......	......	......	......	......	410	14½		Diagram shows increasing speed for 75 ft. Brake not so promptly put in action as compared with other stops.
10	55	53¾	52	48	43	39	35	28	20	7	......	......	......	......	910	21		
12	51	53¼	52	48¼	44¾	40½	36½	30	23	15	......	......	......	......	952	21		
13	56 −	55	53¼	51½	48¼	4.	41½	38	34¾	28¼	23	17½	....	.....	1172	26	....	Steam kept in engine in working notch.
11	51	53½	52	49	46½	43¼	40	37¼	32½	28½	22	14	......	......	1158	26¼	....	Steam on in full stroke.

the experimental van containing recording apparatus; total weight of train 173 tons. Brakes were applied to 54 of the 60 wheels of the train, and 87·88 per cent. of the weight of the train was controlled by the brakes. The train fitted with the Westinghouse brake consisted of an engine exactly similar to the Smith train, tender, nine carriages, one ordinary van, and the experimental brake van, total weight, 166·5 tons; brake blocks applied to fifty of the fifty-six wheels, and 85·75 per cent. of weight controlled by brakes.

The trials were commenced on Tuesday, the 12th of December, but owing to some delay in the preparation on the part of the Vacuum Brake Co., it was postponed to Friday, Dec. 22d, when, everything being in readiness, the trials were proceeded with.

The table taken from *Engineering* gives the results of a number of stops made with each brake, including the successive reductions of speed at intervals of 100 ft. Both brakes were tried on the same day, under similar circumstances, and the same instruments were used in obtaining the results, and with the apparent concurrence of the representatives of both systems.

It will be observed that one great superiority of the Westinghouse brake over the Smith vacuum brake, consists in the promptness with which it is brought into action, and the consequent much shorter distance within which the train is brought to rest.

By observing runs No. 2 of the Smith from Edinburgh to Glasgow, and No. 3 of Westinghouse, it will be seen that the speed of the former at the end of the first 100 ft., after applying the brake, was unchanged, while the latter had reduced the speed from 30 to 28¼ miles per hour, and the distance at which they stopped was 480 and 328 ft., respectively.

This is more marked in the higher speeds, as is seen by comparing runs No. 11 of the vacuum and No. 10 of the Westinghouse, where at 900 ft. the Westinghouse is moving at 7 miles per hour, and is within 10 ft. of stopping, the vacuum train is moving at a speed of 38¼ miles, and has still 475 ft. to go before stopping. K.

Effects of Heat on Voltaic Circuits.—M. W. Hellesen describes numerous arrangements for obtaining very powerful currents, by keeping the liquids around the two plates of an electrolyte at very different temperatures.—*Académie des Sciences; Les Mondes*, Feb. 22, 1877. C.

Hardening of Steel.[1]—By A. Jarolimek (*Dingl. polyt. J.*, ccxxi, 436—446).—It is stated that not only boiling water will harden steel, but that under circumstances, water at a temperature of 150° C. or more will do so, and that boiling hot oil, fluid lead, fluid tin, and even fluid zinc—a cooling liquid of about 400° of heat—will also give similar results. This latter fact is worthy of notice, as it has in general been assumed that steel cannot be hardened unless it be brought down very quickly to a much lower temperature, and that hardened steel softens considerably when exposed to a temperature of 300°; but experiments have shown that the hardness of steel depends upon the quickness with which it is reduced from a temperature of about 500° to one somewhat under 500°. Although the above-mentioned metals are able to harden steel, it was, nevertheless, found that their hardening property could not at all be compared with that of water, this property being in fact influenced not merely by the temperature and the conductivity of the cooling substance, but also by its capacity for heat, its boiling point, and, in the case of a low boiling point, by the amount of latent heat which the vapor contains. For instance, alcohol vaporizes very readily, and as it contains but little latent heat, hardens steel but very badly. Now it is well known that a metal which is heated to a temperature of 1000°, or even only to 500°, must be surrounded by a temperature which renders the existence of water of an ordinary pressure quite impossible. So long as hardened steel possesses this temperature—which it in fact retains until its hardening commences, it cannot be in immediate contact with water, and when plunged into that liquid, must be surrounded by a layer of vapor, which is apt to hold back portions of water near the steel and thus prevent a regular hardening of the latter. It is, of course, improbable that under these circumstances the steel would give up its heat to the water by direct conduction, and as the layer of steam between the metal and the water cannot be superheated to any material extent at so slight a pressure, we must suppose that the water becomes heated by radiation, the layer of water separated by the steel evolving a constant stream of vapor, which condenses on the upper portions of the layer of water. It is shown by calculation that 1 kilo. of steel requires about 0·2 kilo. of water at 20° to lower its temperature from 1000°

[1] Abstracts of Chemical Papers, from the *Journal of the Chemical Society*, for January, 1877.

to 300°; but the reason why a much larger quantity of water is actually required is sufficiently explained, if we consider that (1) the steel has to be moved about in the water; otherwise the formation of vapor would prevent its hardening. (Relying on this fact, it is possible to harden steel under hot water, alcohol, or turpentine.) (2) The vapors condense in the water, and heat a small quantity of it too strongly. Thus it seems that it would be possible to harden steel with a small quantity of water, could the vapor escape as quickly as it is formed. Such, however, is not the case, and the above condensation can, therefore, be facilitated only by the following operations: 1. By plunging the hot steel slowly into the water, the surface of the latter is chiefly acted upon, the vapors having easy access of escape in the air. This method is applicable in cases where the metal above the water remains sufficiently hot to be hardened, *e. g.*, files and other similar articles are easily hardened by this process. 2. A hot and powerful stream of water escaping from a steam-boiler, or an ordinary stream of water, facilitates the hardening by carrying off the vapors as quickly as they are formed. 3. The most satisfactory method is that by which the steel is hardened by means of a thin spray. In this condition the water is largely mixed with air, which, having a very quick and strong action, not only occasions a quick vaporization, but also carries off the vapor formed in a much more complete way than any of the above-mentioned agents. In practice the degree of hardness of steel depends upon the annealing of the latter—a process which always follows the hardening operations. In order to obtain a medium hardness, the steel is cooled slowly throughout the whole of the operation, or it is cooled very quickly to 400°, and afterwards slowly. The former method did not answer in practice, a quick cooling being almost indispensable if satisfactory results are to be obtained. The resulting steel was either of a very hard or of a very soft nature. With regard to the annealing methods, similar experiments were undertaken, the results of which seemed to show that the most profitable form of applying the cooling liquid was when a spray of water was blown on to the steel.

In conclusion, it is stated that fused metals, especially tin, answer very well for hardening small articles. The author was able to harden a steel wire, 3 mm. thick, in a tin bath of 400° of heat, the wire again becoming soft, when it was left in a bath of 350°. On

account of the smaller heat capacity of tin, a large quantity of it is required. One part of steel requires about 45 parts of tin to cool it from 1000° to 300°, if the temperature of the bath before use is 250°, and has not to be raised over 300°.

Glycogenesis.—In the *Annales de Chimie et de Physique*, for July, 1876, Claude Bernard publishes a paper on the formation of sugar-like secretions in animals. He first announced, in his lectures for 1848, that the blood of all animals contains sweet substances, which are secreted by a normal function of the liver, to which he gave the name of the *glycogenic* or *glycogenesic function.* His announcement attracted the attention of many physiologists, who generally sought in the blood the substance from which the sugar is derived. Bernard, on the contrary, found it in the hepatic tissue, demonstrating the fact by showing that after the liver had been carefully washed and freed from all trace of blood, the formation of sugar continued. He subsequently separated a substance which he called *glycogen*, a true animal starch, which E. Pelouze transformed into *xyloidin*, under the influence of fuming nitric acid, and to which he assigned the formula $C_{12} H_{12} O_{12}$. Bernard therefore inferred that both in animals and in vegetables, glucose proceeds from a previous amylaceous substance, and that the formation of sugar in animal livers, after they have been removed from the body, is precisely similar to the same function in a fruit or a tubercule, after it has been separated from a plant. Subsequent investigations showed that the glycogenic function is not confined to the liver, but that it belongs, in a greater or less degree, to many of the tissues, if not to all, and that it is therefore necessary to admit a general glycogeny, instead of a simple hepatic glycogeny. He therefore proposes to investigate a number of special questions bearing on the general issue, such as the formation of sugar in the blood, the formation of glycogenous matter in the liver and in other parts of the body, etc. C.

Temperatures of Combustion.—Berthelot finds that the temperature of combustion of carbonic oxide by oxygen, under constant volume, is comprised between 4000° and 2000°; by air, between 2200° and 1750°. Although his experiments furnish no certain evidence relative to the degree, the nature, or even the existence of dissociation, they seem to establish the possibility of producing real temperatures, in the neighborhood of 3000°.—*Académie des Sciences.* C.

Boiler Explosions due to Grease and Lime.—A commission, appointed to report on a boiler explosion at La Villette, Paris, attributed it to an insoluble deposit, composed chiefly of a calcareous soap, which formed near the opening of the water feed-pipe, and which was due to the nature of the feed-waters. Some of the water was furnished by the city, containing calcareous matters; some came from condensers, bringing fatty particles from the machines, in which they had been used as lubricants. The commissioners cite numerous accidents which have occurred during the past fifteen years, all of which are attributable to the same source. They, therefore, think it important that all manufacturers should be warned of the danger, and if they are obliged to use such a mixture of waters they should use all possible precautions, such as the purification of the calcareous waters by carbonate of soda; the filtration of the condensed waters, by passing them through wool or felt; the skimming of the grease from the surface of condensing cisterns; and frequent drawings off from the surface of the water in boilers.—*Ann. des Ponts et Chaussées.* C.

Sugar Production in Europe.—The *Journal des Fabricants de Sucre* gives the following table, representing the number of tons of sugar manufactured in Europe, during the past four years:

	1876–7.	1875–6.	1874–5.	1873–4.
Germany,	280,000	346,645	250,708	289,243
France,	225,000	462,259	450,877	396,578
Russia,	250,000	245,000	222,500	202,851
Austria,	150,000	153,922	120,720	167,058
Belgium,	55,000	79,796	71,079	73,516
Holland, etc.,	30,000	30,000	30,000	35,000
	990,000	1,317,622	1,145,884	1,164,246

The editor thinks that the deficiency for the present year will be greater than appears from the estimate in the table, and that it may probably reach 440,000 tons. So large a deficit may, perhaps, lead to still further advances in the price of sugar. C.

Prize to Sir William Thomson.—The Italian Society of Sciences, or the "Society of the Forty," has awarded to Sir William Thomson, professor of the natural sciences in the University of Glasgow, the prize instituted by Carlo Matteucci for the investigator, who, by his writings or his discoveries, has contributed most to the advancement of science.—*Ex.* C.

Silver Refining.—M. Debray states that silver ingots are often found with a fineness of ·998 or ·999, which work badly with those of ·950, giving surfaces with gray spots which can hardly be removed by polishing and which always reappear under gilding. This property is due to the presence of selenium in the sulphuric acid which is made from pyrites, and refiners should, therefore, be very careful in the selection of their acid. As the selenium oxidizes easily, it may be separated by melting the silver precipitated by the copper, in an oxidizing atmosphere, or in the presence of nitrate of potash or soda. —*Ex.* C.

Cometary Spectrum.—On February 16, Father Secchi found the spectrum of Borelly's comet, formed of three bright bands: one in the middle, large and brilliant, in the green; another, narrower and more refrangible, in the blue; a third, still narrower, more difficult to separate and less refrangible.—*Ex.* C.

New Horse-Shoe.—Mr. Yates, of Manchester, has invented a horse-shoe, composed of three thicknesses of cow-hide, compressed into a steel mould, and then subjected to a chemical preparation. It lasts longer, and weighs only one-fourth as much as the common shoe; it never splits the hoof, and has no injurious influence on the foot. It requires no calks; even on asphalt, the horse never slips. It is so elastic that the horse's step is lighter and surer. It adheres so closely to the foot, that neither dust nor water can penetrate between the shoe and the hoof.—*Les Mondes*, March 1, 1877. C.

Water Supply of Turin.—In 1832, Queen Maria Christina, widow of King Carlo Felice, requested Engineer Ignazio Michela, to devise a plan for supplying Turin with wholesome water for the charitable institutions and public fountains. Sig. Michela made a report in 1842, describing six different sources from which a supply could be drawn. In 1847, through the efforts of Count Filiberto di Collobiano, Secretary of the Queen, a commission was appointed with a view to organize a company on a broader basis, to introduce drinking water for the entire population. After examining various plans, two were selected for the final choice; one, to use the subterranean waters between Pianezza and Collegno, by means of deep wells connected by a gallery; the other, to combine the numerous springs in

the valley of the Sangone. For various reasons the preference was given to the latter, although it was estimated that it would cost 300,000 lire[i] more than the other. A company was organized, under a royal decree of April 10, 1853, with a capital of 3,000,000 lr., divided into 6000 shares.

After surmounting numerous obstacles, in the way of proprietary claims, suits against individuals and corporations, and unexpected delays, a reservoir was erected, having a capacity of 4000 cubic metres, with networks of tributary galleries in various directions, and large purchases were made which raised the estimated supply to 200 litres per second, or something more than 16,000 cubic metres per day. From the collecting reservoir the waters were carried by a well-cemented vaulted gallery in the subsoil at a mean depth of 3 metres to the "Baraccone," at the side of the highway to Rivoli. The gallery was 1 metre wide, 1·75 m. high, 12,290 m. long, with a declivity of 4·2 ft. per mile, interrupted only by iron siphons for the passage of streams, canals or depressions. From the Baraccone reservoir the water is led in a tube of 45 centimetres internal diameter, 7300 metres into the city, and 9604 metres to its discharge into the Po. The level of the water, at its entrance into the tube, is 45 m. above the ground-surface, at its arrival in the Via di Doragrossa at Porta Susa.

On March 6, 1859, the works were publicly inaugurated by the opening, on the Square "Carlo Felice," of a magnificent fountain, which threw a jet of 38 metres. By means of a loan of 1.200.000 lr., contracted under the guarantee of the Municipality, the company extended its main and tributary galleries and built a filtering reservoir, thus increasing the supply and the conveniences of distribution. It was under obligations to supply the city authorities with 25 litres per second, at the rate of 3 centesimi[ii] per cubic metre, and to limit the rate for private citizens to 23 centes., which was reduced, by discounts and concessions, to an average rate of 17 centes. The great superiority of the water over that of the wells, was speedily recognized, and its use rapidly extended, in cafés, inns and private houses. The efficacy for extinguishing fires, through the force consequent on the great head, multiplied the number of fire-plugs under

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[i] The Italian *lira* is equivalent to the French *franc*.

[ii] A *Centesimo* is equivalent to 2 mills.

the care of the government, the city, the insurance companies, and private citizens. Thus the company's revenue, which was 12,435 lr. in 1859, reached 279,000 lr. in 1875, and the service-pipes, at the end of 1873, aggregated 53,000 metres.

Notwithstanding the new sources of supply which the company from time to time acquired, an extraordinary drought in the year 1861, showed that the demand had already exceeded the permanent supply. The drought continuing, in varying degrees, through the eleven subsequent years, it was soon found that none of the original estimates were trustworthy, and that there were grave doubts whether the company would be able to carry out its existing contracts, to say nothing of the new ones for which it was continually solicited. In 1867, Sig. Claudo Calandra, from whose memoir the present account is abridged, accompanied by other engineers who were officially or temporarily connected with the company, began a series of geological explorations of the neighboring districts. New excavations and galleries were consequently decided upon and let out to contractors, who began operations in the latter part of summer, 1872. The new works were twice destroyed by extraordinary inundations of the Sangone, but the "proverbial Piedmontese firmness and obstinacy" prevailed over all obstacles, and by tapping new water-sheets, an actual supply of 100 litres per second was secured, but one-fourth was lost by overflow, leakage, and unknown causes of waste. All immediate apprehensions of a water famine are removed, but the growth of the city, the creation of vast vegetable and flower-gardens, the growing demands of public cleanliness, the rapid multiplication of baths, dye-houses and laundries, will soon require a still further and more radical enlargement of the regular stated service.—*Il Politecnico*, xxv, Nos. 1 and 2. C.

Book Notices.

Elements of Geometry. By G. M. Searle, C.S.P. 8vo, pp. 135. New York, J. Wiley & Sons.

The author's desire is to reduce the number of axioms to a minimum, and to introduce a new method of treatment for the subject of parallels. Other modifications are also noted. Definitions are reserved until needed, which is an improvement on the old methods. The chapter on proportion is omitted. The theory of the formation

of bodies by the continuous motion of points, lines and surfaces leading directly to fluxions, is also an improvement, but we cannot commend the apparent ambiguity existing in some of the theorems (Prop. 13, p. 11; Prop. 26, p. 19), nor the change produced in familiar and almost stereotyped propositions by the desire to produce something original. Moreover, most mathematical writers have agreed to call the circumference the bounding *line* of the *area* called the circle; by assuming to reverse the order, it leads to confusion from the very inception of the science, and leaves the bounding line nameless.

Segment and sector are always understood to mean areas, and so they are used here, yet the author defines them as parts "of a circle," etc.; now, if a circle be a *line*, as he determines to call it, how can the sector (an *area*) be a part of it? The word circle must always have, in this treatise, a double meaning—and hence be ambiguous. The idea of a plane, generated by one line, revolving about another to which it is perpendicular, limits it to a *circle*—a particular form of a more general class of figures.

The entire work, including a good collection of problems and an appendix, is compact and well printed, and we think will be enjoyed by mathematicians generally. H.

TEXT-BOOK OF MINERALOGY. By Prof. Edward S. Dana. 8vo., pp. 485. New York, Wiley & Sons.

This long expected work, begun years ago by Prof. J. D. Dana, supplies the great need of a text-book of mineralogy for schools and colleges. In the last edition of Prof. J. D. Dana's mineralogy, the descriptive portion, synonyms, etc., were made full and complete, so much so as to make that book the standard, not only of this country, but almost of the world. The space required to do this as thoroughly as it was done, prevented full justice to any other department; this want is now supplied. The book is written concisely, but clearly, and conveys much information in few words. The descriptions of all the more common minerals, while necessarily briefer than those of the larger work, are sufficient. The rarer species are enumerated and a brief description given. One very valuable feature has been introduced: a brief summary of the easily detected differences between the mineral under description and those which it most resembles.

We notice that the recent discoveries, chiefly in our own state, in regard to the mineral damourite, which are among the most remarkable of recent discoveries in the science, appear to have been overlooked. There are other minor omissions, but they detract but little from the value of the book for the purpose designed. R.

Civil and Mechanical Engineering.

CERTAIN POINTS IN THE DEVELOPMENT AND PRACTICE OF MODERN AMERICAN LOCOMOTIVE ENGINEERING.

By FRANCIS E. GALLOUPE, S. B.

[Continued from Vol. ciii, page 264.]

Now this is diminished by the volume of the internal staying, and, although it was supposed that this would be inconsiderable, a correction was made for this. The arrangement of these stays caused the quantities by which the capacity was to be corrected, to be of two kinds. First, a constant correction for every depth, consisting of the volume of the perpendicular parts, the upright sheet-iron stays and rods, which amounted to 1379·62 cu. in. = ·795 cu. ft. = 5·94 gallons; and second, a part, consisting of the angle iron two inches high, running around the bottom edge of the tank, and the angle iron and horizontal stay rods which were found to be at a height of $22\frac{7}{8}$ inches above the bottom. This amounted to 919 cu. in. = ·532 cu. ft. and $\frac{\cdot 532}{2}$ (= ·266) $\times$ 7·4805 = 1·9898 gallons per inch of height, or 1·9898 $\times$ 4 = 7·9529 gallons in all. The ultimate correction was therefore 13·906 gallons, and the real capacity 2502·3836 gallons.

This process was gone through four times, and the capacities found were as follows:—1st trial, 2453·23 gallons; 2d trial, 2519·44 gallons; 3d trial, 2465·57 gallons; and 4th trial, 2502·38 gallons, the variations depending on very slight differences indeed, in the measurements and decimal places.

Incidentally, the weight of the water contained in the tender when full may be here stated. It amounted to
336·3799 cu. ft. $\times$ 62·4 = 20,990 lbs. or 10·495 tons.

Now, in order to calculate columns 16 and 17, the cubic feet of water corresponding to each inch of height of tank were obtained. Multiplying the area 94·1743 sq. ft. by ·0833 ft. (= 1 inch) we

obtain 7·8445 cubic feet of water in the tender for each inch of height when uncorrected for the staying and angle iron. For the corrected capacity we have 7·8445 — ·266 cu. ft. = 7·5785 cu. ft. This is to be used only for the first two inches at the bottom and for from $21\frac{7}{8}$ to $23\frac{7}{8}$ inches depth. Table VII gives the depths of water taken, and the coefficients by which these two columns have been obtained.

It shows the water and coal consumption during all the trips, and also the relative amounts used on the same portions of the road on different days. Now, on Wednesday, it seems, 26 inches depth of water were consumed in carrying the train from Boston to Ipswich. Therefore, there are 26 — 2 = 24 inches to be multiplied by 7·8445 cu. ft., or 188·2680 cu. ft. Now, the other two inches lying between $21\frac{7}{8}$ and $23\frac{7}{8}$, are to be multiplied by the corrected capacity per inch of depth, which gives 2 × 7·5785 = 15·1570. Or, the total number of cubic feet of water consumed in running 27 miles is
188·268 + 15·157 = 203·425, and this is the first number given in column 5.

Now, the number of cubic feet of water consumed between the stations, column 16 (of Tables I-VI), is calculated *on the supposition that the rate of evaporation is proportional to the coal burned*, and in this case, the amount of coal was 1323·1 lbs. Hence,
203·425 ÷ 1323·1 = ·154 cubic ft., the average amount consumed per lb. of coal; and multiplying this coefficient by the number of pounds of coal burned between the stations, respectively, the results given in column 16, were obtained; and those in column 17, by dividing those in column 16, by the number of miles between the stations, respectively, and multiplying by 62·4, the weight of a cubic foot of water.

It will be seen that these coefficients and averages vary greatly on different parts of the road and on different days.

The depths taken at Newburyport and Salem, where no water was taken on, serve simply as checks. For instance, on Thursday, between Ipswich and Portsmouth, a distance of 29 miles, $15\frac{3}{4}$ inches of water were used, or ·54 inch per mile. Now, Newburyport being 10 miles from Ipswich, we might expect that there would be used in going that distance, 10 × ·54 = 5·4 inches, leaving
42·75 — 5·4 = 37·35 inches in the tank. But, by the record, it seems that there were actually but 36 inches at Newburyport, which

TABLE VI.—Trip No. 6.

DATA AND RESULTS FROM HINKLEY ENGINE No. 55, EASTERN R. R., ON BANGOR TRAIN, RETURN TRIP.

Date: Friday, March 17th, 1876.
Day: Weather, wet and icy.—Wind, E.

At Portsmouth: *Coal taken on, none.* *Depth Water in Tender at starting, 41½ inches* *Number of Cars, 7.*

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
			Time Record.			Coal Record.			Speed Record.						Water and Steam Record.		NOTES.
Miles from Portsmouth.	Train Due. Time.	Station	Train Arrivals and Leavings. Corrected time by watch.	Length of Stop.	Steam Pressure. Gauge Readings.	Weight fired between stations.	Aggregate weight.	Pounds of coal consumed per mile run.	Cut-off. Inches of stroke.	Steam Pressure at time of observing speed.	Revolutions per minute.	Feet per minute.	Max. Rate observed. Miles per hour.	Average Rate. Miles per hour.	Cubic Ft. of Water consumed between stations.	Weight of water or steam consumed per mile	Oiling, Shutting Off, Braking, Stirring Fire, Air Brake Pressure, etc.
	H. M.	Leave	H. M. S.	M. S.	LBS.	LBS.	LBS.			LBS.						LBS.	
	A. M.		A. M.														Valve began to blow off at 140 lbs.
						47 3			10	127	126	2061	23 4†				† Very heavy up-grade. Time, 11.26.00.
	11 18	Portsmouth	11 24 25		135	418 5	465 8		10	109	270	4418	50 2†		48 909		† Up-grade Time, 11.31.00
									10	113	240	3927	44 6†	29·5		610·4	† Time, 11.32.00. Shook grate.
5	11 28	*Greenland	11 34 35		122	148 5	614 3	93	14						15 593		At Portsmouth 31 shovelfuls put in. Weather clearing off.
			ar. 40 25						10	108	150	2454	28 3†	20·6		455·3	† At stone overhead bridge. Time, 11.37.00
7	11 35	North Hampton	11 40 45	20	115	94 5	708 8	74	10	106	250	4090	46 5†		9 923		Oiled cylinders. [a down-grade.
									14	104	110	1800	20 5†	31·9		206 4	† Time, 11.39.00. Partly on an up-grade and over a ridge upon
10	11 42	Hampton	11 46 25	...	110	121 5	830 3	32	10						12 758		† Heavy up-grade. Time, 11 43.00. Stirred fire.
									10	103	250	4090	46 5†	26·1		265 3	† Time, 11.49.00.
13	11 47	*Hampton Falls	11 53 20		108	189 0	1019·3	41	10	98	250	4090	46 5†		19 845		† Time, 11.50 00.
									10	102	130	2127	24 2†				† Very heavy up grade. Time, 11.57.00.
14	11 50	*Seabrook	... ...		......	......								33·9	......	309 5	No stop made. Stirred fire.
			P. M.						......	......	......	......	......				
17	P. M.	*Salisbury	12 00 25		103	40 5	1059·8	47	6						4·253		No stop. Weather, cloudy but dry.
			ar. 04 15						......	......	......	......	......	31·3		132·7	At Newburyport, depth water in tender, 28 in.
19	12 05	Newburyport	12 06 40	2 25	138	60 8	1120·6	20							6·384		Oiled cylinders.
		Know-nothing	12 09 55	...	136	20 3	1140·9		......	......	......	......	......	24 8	2 132	177 2	
22		*Knight's Crossing	12 13 55		120	108 0	1248 9	27	6						11·340		Stirred fire. Cylinder cocks opened.
									6	109	200	3273	37 2†	38·3		176·9	† Time, 12.17.00. Taken on the up-grade to cut.
26		*Rowley	12 20 10	...	120	108 0	1356·9	27	10						11·340		Cylinder cocks opened. Made a stop
			ar. 26 40						10	120	200	3273	37·2†	27·7		235·9	† Time, 12.24.00. Register in fire-door open.
29	12 28	Ipswich	12 32 40	6 00	138	216 0	1572 9	36	10						29 808		Foggy. Stirred fire [41¼ in.
			ar. 42 50						10	99	220	3600	40·9†	29·5		371 9	At Ipswich: Depth water, before filling, 23¼ in.; after filling,
34	12 40	Wenham	12 44 05	1 15	123	74 3	1647 2	43	10	113	170	2781	31 6†		10·253		† Time. 12.39. Began to snow. Very heavy up-grade, time, 12.47.
									10	106	200	3273	37 2†	28·8		319 9	† Time, 12 48.00. Oiled cylinders from cab. [¼ m. Stirred fire.
36		*North Beverly	12 48 15		106	27 0	1674 2	37	6	113	360	5891	*67·0†		3·726		† Time, 12 50 15. This is partly estimated Counted 90 revs. in
			ar. 52 30						6	113	300	4909	55 8†	28·1		116 3	† Taken immediately after the preceding.
38	12 48	Beverly	12 53 25	55	122	81 0	1755·2	14							11·178		Counted 150 revs. in ½ minute
			ar. 56 45						......	......	......	......	......				Snowing very fast.
		Know-nothing	12 57 00	15	121	33 8	1789·0							18 2	4 664	494·2	Oiled engine outside.
			ar. 00 00														† Blew off at 139 lbs., pressure suddenly rising to 141 lbs.
40	12 58	Salem	1 01 50	1 50	139†	270 0	2059 0	57	10						37·260		
									10	121	170	2781	31 6†	30·5		581 3	† Time, 1.06.00. Up-grade, though not very heavy.
44		Swampscott	1 09 40		102	00 0		68	10						......		
			ar. 12 20		112				10	104	120	1963	24 1†	22·5		....	† Time, 1.11.00.
45	1 11	Lynn	1 13 30	1 10	129	40 5	2099 5	00	10						5·589		Stirred fire. Oiled cylinders.
									10	......	70	1145	13·0†	23·2		348·8	† Time, 1.16.00.
46		West Lynn	1 16 05		123	87 8	2187·3	41	10						12 116		Stirred fire.
									6	116	200	3273	37·2†				† Time, 1.19.00.
		Oak Island	1 20 45		111	27·0	2214 3		6					31·3	3·726	247·1	
									......	......	......	......	......				
50		Revere	1 23 45		108	27·0	2241 3	29	6						3·726		
									6	107	200	3273	37·2†	15·7		232·5	† Time, 1.25.30.
51	1 28	Chelsea	1 27 35	...	120	47·3	2288 6	27	10						6·527		Stirred fire.
									10	112	160	2618	29·8†	31·3		203·6	† Time, 1.31.00.
53		Everett	1 31 25		111	60·8	2349 4	24							8·390		
										......	......	......	......				
		Curve at Somerville	1 33 25		106	13·5	2362 9		17					19·5	1·863	639·8	Slowed down for draw.
			ar. 34 30														Rate of speed, about 250 revs. per minute.
54		Somerville	1 34 50	20	116	00·0		74	17						......		
		B. & M. R. R. Crossing															
			† 37 30		113												
		Prison Point	1 41 50	4 20	133	00 0		00									† Delayed at Prison Point by a freight train on the Fitchburg R. R. Crossing.
														12·9†		......	At Boston.—Watch 50 secs fast at 1.48 P. M. Estimated coal left in tender, 2 tubs.
							Tot. for 56 miles run.								......		
56	1 45	Arrive at Boston	1 44 10		......			00	......	......	......	......	......			......	Depth water in tender on arrival, 23½ inches.
			Average steam pressure, 119 lb.				Av. lb. coal per mile, 38						Average,	26 5	Average,	322 4	

* Flag Stations.

* Maximum speed observed during all the trips.

TABLE VII.—Water Record.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		Wednesday, March 15th. Tables I & II.					Thursday, March 16th. Tables III & IV.					Friday, March 17th. Tables V & VI.				
Miles.	Watering Stations.	Depths Taken	Difference.	Cubic Feet Water Consumed.	Pounds of Coal Consumed.	Cu. ft. per lb. of Coal.	Depths Taken.	Difference.	Cubic Feet Water Consumed.	Pounds of Coal Consumed.	Cu. ft. per lb. of Coal.	Depths Taken.	Difference.	Cubic Feet Water Consumed.	Pounds of Coal Consumed.	Cu. ft. per lb. of Coal.
		IN.					IN.					IN.				
27	Boston	42	26	203·425	1323·1	·154	40	20	156·358	924·8	·160	41	15	117·668	1531·3	·077
	Ipswich	16 / 41½					20 / 42¾					26 / 11				
29	(Newburyport)	....	10¼	80·406	1410·8	·057	36	15¾	123·550	999·0	·124	34¾	20	156·358	1525·6	·193
	Portsmouth	31¼ / 10¼					27 / 42					21 / 41½				
29	(Newburyport)	....	23	179·892	1640·3	·109	30¾	17½	137·279	1005·8	·136	28	18¼	142·996	1356·9	·105
	Ipswich	17¼ / 42					21½ / 42					23¼ / 41¼				
27	(Salem)	....	18¾	146·918	931·6	·157	33¾	16	125·512	864·0	·145	....	17¾	139·140	1006·0	·138
	Boston	23¼					26					23½				

shows that the consumption was not strictly proportional to the distance run.

We cannot discuss, in full, the facts relating to the water consumption indicated by these figures, but a single example will suffice. Let us consider the water consumption in running the train from Boston to Portsmouth on Thursday. The volume of one cylinder is 4825·497 cubic inches, or 2·792 cubic feet, and the cylinder capacity, equal to the steam required per revolution, 11·168 cubic feet. The average steam pressure for the trip was 131 lbs., and the weight of a cubic foot of steam under this pressure, being ·32592,[1] that required per revolution would be $11·168 \times ·32592 = 3·64$ lbs. Now, the circumference of the wheels being 16·36 feet, $5280 \div 16·36 = 322·27$ revolutions would be made, if there was no slip, in a mile, and there would be required $322·27 \times 3·64 = 1173·06$ lbs., or $\frac{5}{12}$ of this, equal to 488·775 lbs. of steam per mile when cutting off at the usual point, 10 inches of the stroke. Now, it appears, by column 17, that in but one case was this great amount actually used, the average being but 364·1. To make this difference more plain, for the 56 miles there would apparently be required $488·8 \times 56 = 27,372·8$ lbs. of water. On the other hand, by the table, we know it to be a fact that but $156·358 + 123·55 = 279·9$ cubic ft. or 17,465·76 lbs. were used. If we attempt to explain this by the reduction of pressure in the cylinder, assuming it to be 20 lbs. less, or 111 lbs., the weight of a cubic foot of steam would then be but ·28625, or $·28625 \div ·32592 = ·878$ that in the former case, and the apparent consumption would be 24,033 lbs. It seems that the whole tendency is also to increase rather than diminish this difference; the air brake was working most of the time, any slipping of the wheels would increase it because the valve would open oftener, and still more would be lost through the safety valves, the blower, leakage of all sorts, and the use of the injector. The only cause I can assign for it, unless the point of cut-off was at any time less, or excessive reduction of pressure in the cylinder by wire drawing occurred, is the saving of steam on down grades, and that due to the distance traveled by reason of the momentum of the train, after the steam was shut off on approaching stations. The amount of water in the boiler was kept pretty constant during all parts of the trip.

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[1] Porter.

Another point to be noticed is the great apparent evaporative power and efficiency indicated. The average evaporation for all the trips is ·123 cubic ft., or 7·6752 lbs. of water per lb. of coal, which gives an apparent boiler efficiency of $e = \frac{E'}{E} = \frac{7 \cdot 675}{10 \cdot 92} =$ over 70 per cent., while we have found its maximum real efficiency to be probably not more than ·557. This probably shows that there was 14 or 15 per cent. priming.

In the column of notes there are a number of facts in regard to the manner of stopping the engine, the air-brake pressure, and time required to stop the train from full speed.

In order to be certain that the engine which has been selected was not exceptional in any of the conditions under which it worked, similar data have been taken from the Mason engine No. 36, on three Rockport trips, but they have not yet been worked out. The accompanying record (Table VIII) of the performance of eight of the best engines upon the Eastern Railroad, this one included, for the month of January, 1876, will answer the same purpose.

Before we leave this subject, the discussion of the tables would be incomplete if no allusion were made to the power exerted by this locomotive, and for the purpose of investigating this let us select the data furnished in Table II, on the return trip, Wednesday, and the straight and level piece of track, four miles in length, between West Lynn and Revere. Although the term, horse power, is applicable to stationary rather than locomotive engines, since, as a general distinction, the office of the latter is to draw a load rather than to lift a weight through a certain height, its power can be reduced to an equivalent horse power, and this is equal to the product of a certain weight attached by a rope to the circumference of one of the driving wheels, into a certain height through which it is lifted, per minute, divided by 33,000. Since the power exerted is equal to the gross work performed, it may be represented, calculated from the effective steam pressure and the speed, as follows:—

$H. P. = \frac{p \times 2 \times A \times 2 \times S \times N}{33,000} = \frac{4 p A S N}{33,000}$. It therefore depends upon the effective pressure, p, per square inch, exerted through the whole stroke; the joint area, $2 A$, of the two pistons; the length of stroke, S, in feet; and the number of revolutions, N, per minute. Now, the average speed, by the table, is seen to have

TABLE VIII.

Performance of Engines of the Eastern Railroad Company. Month of January, 1876.

Number of Engine.	NAME.	Where Made.	Size of Cylinder.	Kind of Service.	Miles Run.	COAL. Tons.	COAL. Pounds.	COAL. Miles run to one ton of Coal.	WOOD. Cords.	WOOD. Miles run to one cord	OIL. Pints.	OIL. Miles run to one pint of Oil.	WASTE. Pounds.	WASTE. Miles run to one pound of Waste.
27	"Chelsea.".........	Hinkley.........	16 x 24	Pass.........	519	11	960	50	½	....	32	17	11	50
51	"Everett.".........	"	16 x 24	Freight.....	2284	55	300	42	1⅝	....	108	21	55	42
52	"Bangor.".........	R. I. Works....	16 x 24	Pass.........	1992	32	1960	60	1	....	118	17	50	36
55	No name.........	Hinkley.........	16 x 24	Pass.........	3016	53	1280	56	1	....	182	17	55	55
56	"St. Lawrence."...	....	13 x 20	Pass.........	2382	30	1200	77	1½	....	156	15	33	72
58	"Massachusetts."...	Hinkley.........	16 x 24	Freight.....	2063	42	2220	48	1½	....	124	17	53	39
60	"America.".........	R. I. Works....	16 x 24	Pass.........	2704	56	2160	47	¾	....	168	16	55	49
75	No name.........	E. R. R. Works	17 x 24	Pass.........	2802	46	2160	60			152	18	44	64

TOTALS AND AVERAGES

For 90 Locomotives on the Eastern Railroad for the Month of January, 1876.

	Average.	Average.
Cost of Coal per Ton,	\$6.00;	per mile run, 10·5 cents.
" Wood per Cord,	5.12;	" " 17·6 "
" Oil per Pint,	.09⅛.	
" Waste per Pound,	.08¼.	

	Total.	Miles run to	Average.
Tons of Coal used,	$2,233\frac{2030}{2240}$;	One Ton of Coal,	57
Cords of Wood used,	1,050;	One Cord of Wood,	29
Pints of Oil used,	8,677;	One Pint of Oil,	18
Pounds of Waste used,	3,078;	One Pound of Waste,	50

been 30·5 miles per hour. Let us call it 30. In a mile without slip, the wheels would make

$\frac{5280}{16 \cdot 36} = 322 \cdot 7$ turns, or $N = \frac{30}{60} \times 322 \cdot 7 = 161$ revolutions per minute. Let us at first assume the boiler pressure at its maximum of 140 lbs., and let it be reduced 20 lbs. in its transmission to the cylinder. Let it further be assumed that the pressure of 120 lbs., or 134·7 lbs. absolute, continues constant to the point of cut-off at 10 inches of the stroke. The ratio of expansion will hence be $\frac{24}{10} = 2 \cdot 4$, the hyperbolic logarithm of which is ·8754. Dividing this log. + 1, by 2·4, we obtain ·781 by which to multiply the mean absolute pressure, 134·7 lbs., during admission. This gives 105·2 lbs. for the mean absolute pressure during the stroke, or 90·5 lbs. for the mean effective pressure, p. Hence there will be 201 (sq. in. area) $\times$ 90·5 = 18,190·5 lbs. pressure constantly exerted upon each piston, or the entire pressure, $P = 36{,}381$ lbs. The space through which this acts per revolution is 2 $\times$ the stroke of 2 feet, and multiplying this by the number of revolutions, $N = 161$, we obtain 23,429,364 foot-pounds of work that this engine can perform per minute under these conditions. The equivalent horse power is therefore $\frac{23{,}429{,}364}{33{,}000} = 710$ *H. P.*

The Tractive Power of an engine is limited by the amount of adhesion of its coupled wheels to the rails. The weights of the principal parts of this engine, which determine its amount, and also those of the tender and train which it was drawing at this time, are as follows:—

Driving Wheel Centres, 4 @ 1480 lbs., .	5,920 lbs.	
Frame, ...	3,200 "	
Boiler, with tubes, empty, . .	9,800 "	
Water in boiler to 2d gauge (50 cubic feet), ...	3,120 "	
Weight on the Driving Wheels, .	40,540 "	
Weight on the Truck, . . .	23,800 "	
Weight of Engine alone, in working condition, with two gauges of water, .	64,340 lbs.	= 32·17 tons.
Tender, empty, . . .	20,000 "	= 10· "

Water contained in Tender, .	20,990 lbs.	= 10·5	tons.
Coal contained in Tender, . .	6,000 "	= 3·	"
Tender with water and coal, .	46,990 "	= 23·5	"
Maximum weight of Engine and Tender,	111,330 "	= 55·7	"
Average weight of coal and water in Tender, = $\frac{2}{3}$ maximum, . . .	17,994 "	= 8	"
Average weight of Tender with water and coal, ...	37,994 "	= 19	"
Total weight of Engine and Tender with average load, . . .	102,334 "	= 51·2	"
Weight of Train, 7 cars with average load @ 22 tons apiece, . . .	308,000 "	= 154	"
Total average weight of Engine, Tender and Train, ...	410,334 "	= 205·2	"

The friction of the driving wheels upon the rails, or the adhesive weight, is usually taken at $\frac{1}{5}$ the weight resting upon them, or, in this case it would be 8108 lbs. According to Weissenborn's "American Locomotive Engineering," the number of lbs. adhesive weight per ton of load on the driving wheels varies with the condition of the rails and weather as follows:—with dry rails, 600 lbs. per ton; wet rails, 550; damp, 450; foggy weather, 300; and ice or snow on the rails, 200. In this case the rails were dry and the corresponding adhesion which could not be exceeded by the tractive force, $= 20{\cdot}27 \times 600 = 12{,}162$ lbs. The tractive power is found by dividing the foot-pounds exerted per revolution by the circumference of the wheel. By the table the actual steam pressure was 98 lbs. Subtracting 20 lbs., we find, in the same manner as before, that the mean effective pressure is but 57·7 lbs., the foot pounds of energy developed per revolution but 92,780, and the ultimate horse power that could be exerted under these conditions, 452 H. P. The tractive power, or force exerted to move the engine with its train one foot is therefore $T = \frac{2\,p\,A{\cdot}2\,S}{2\,\pi\,R} = \frac{92{,}780}{16{\cdot}36} = 5671$ lbs.

To conclude the discussion of these data I have made a table of summaries (Table IX) which will be briefly described.

Column 5 = differences of col. 4.

Column 9 = col. 8 × 13·5 lbs., weight of one shovelful of coal.

TABLE IX.

Synoptical Table of Results.

1	2	3	4	4	5	6	7	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
			Time Record.						Coal Record.						Water and Steam Record.				Steam Pressure.		Record of Speed.											Locomotive Power.					Duty.
Trip.	Date.	Terminal Stations.	Time of leaving Stations.		Duration of Trips.	Number of Stops.	Total Duration of Stops observed.		Number shovelfuls fired between termini.	Pounds consumed per trip of 56 miles.	Av. pounds consumed per mile run.	Miles run per ton of coal.	Av. pounds of coal consumed per minute.	Mean rate of combustion.	Depths used.	Equivalent cubic feet.	Av. cubic feet per mile run.	Av. cubic feet consumed per pound of coal.	Number of observations of Gauge.	Av. of Gauge Readings.	Max. speed observed. Revolutions per minute.	Max. speed observed. Feet per minute.	Max. piston speed obs'd. Feet per minute.	Max. speed observed. Miles per hour.	Steam pressure at time of observing speed.	Cut-off. Adm'n—in. of stroke.	Cut-off. Decimal of stroke.	Mean speed per trip. Revolutions per minute.	Mean speed. Feet per minute.	Mean piston speed. Feet per minute.	Mean speed. Miles per hour.	Average tractive power.	Av. foot pounds exerted per minute, calculated from steam pressure and speed.	Equivalent indicated horse power developed.	Pounds of water consumed per horse power per hour.	Pounds of coal consumed per horse power per hour.	Apparent duty per 100 lbs. of coal, calculated from indicated horse power.
			H. M.	S.	H. M. S.		M.	S.							IN.					LBS.					LBS.							LBS.					FT. POUNDS.
	1876.	Boston........	8 30	34																																	
1	Wednesday..	Portsmouth.	11 01	00	2 30 26	13	7	40	202½	2,734	56	40	18·1	73·2	36¼	283·83	5·07	·1055	25	127	240	3927	960	44·6	114	10	·416	120	1962	480	22·3	7,520	14,664,960	444	15·9	2·4	81,021,900
		Portsmouth.	11 26	35																																	
2	March 15....	Boston........	1 49	15	2 22 40	13	11	35	190½	2,572	55	43	18·0	72·6	41¾	326·81	5·83	·1330	29	115	240	3927	960	44·6	104	10	·416	127	2077	508	23·6	6,827	14,090,904	427	20·1	2·5	78,282,800
		Boston........	8 31	00																																	
3	Thursday....	Portsmouth.	10 57	45	2 26 45	14	13	05	142½	1,924	41	58	13·1	52·9	35¾	279·91	4·99	·1475	33	131	260	4255	1040	48·4	128	8	·333	123	2015	492	22·9	6,827	12,647,096	383	18·7	2·0	96.542.700
		Portsmouth.	11 22	45																																	
4	March 16....	Boston........	1 42	25	2 19 40	15	16	15	138½	1,870	34	60	13·4	54·2	33½	262·79	4·69	·1403	26	133	290	4745	1160	53·9	126	6	·250	130	2121	520	24·1	5,739	12,124,320	367	19·2	2·2	90,480,000
		Boston........	8 31	20																																	
5	Friday........	Portsmouth.	10 56	40	2 25 20	15	14	55	226½	3,057	64	37	21·0	84·6	35	274·03	4·89	·0898	32	132	270	4418	1080	50·2	127	10	·416	124	2033	496	23·1	7,817	15,751,968	477	14·8	2·6	75,009,400
		Portsmouth.	11 24	25																																	
6	March 17....	Boston.......	1 44	10	2 19 45	14	18	50	175	2,363	38	47	16·9	68·4	36	282·14	5·04	·1215	28	119	260	5891	1440	67·0	113	8	·333	129	2112	516	24·0	6,135	12,860,784	390	24·0	2·6	76,099,300
Total Averages and Aggregates.....					2 24 06		Ag. 82	20		Ag. 14,520	48		16·8	67·7		Ag. 1709·51	5·09	·1229	Ag. 173	126						9	·375	126	2053	502	23·3	6,811		415	18·8	2·4	82,906,000

Number of trips, 6.
Miles per trip, 56.
Total number miles run, 336.

Times, { Total duration of trials, 15 hrs. 42 m. 55 secs.
Time running, 13 hrs. 2 m. 15 secs.
Time not running, 2 hrs. 40 m. 40 secs.

Total average load, 205 tons.
Capacity of each cylinder, 4,824 cu. in. — 2,792 cu. ft.
Area each piston, 201 sq. in.

Circumference driving wheels 16·36 feet.
Maximum curve on section of road run over, 1200 feet radius.
Apparent gross evaporation of water = 1709·51 × 62·4 (col. 15) ÷ 14,520 (col. 9) = 7·35 lbs. per lb. of coal.

Water cont
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summaries (

Column
Column

Column 10 = col. 9 ÷ 56, miles per trip.

Column 11 = 56 ÷ tons in col. 9.

Column 12 = col. 9 ÷ col. 5.

Column 13 = col. 12 ÷ 14·84, area grate, and × 60, minutes in an hour.

Column 16 = col. 15 ÷ 56 miles.

Column 17 = col. 15 ÷ col. 9.

Column 21 = col. 20 × 16·36, circumference driving wheels.

Column 22 = col. 20 × 4 ft. for piston speed, = stroke × 2 × number of revolutions.

Column 30 = 56 miles ÷ col. 5. This speed is inclusive of stops.

Column 28, since 1 mile of 5280 ft. ÷ 60 = 88 ft. per minute, it = col. 30 × 88.

Column 27 = col. 28 ÷ 16·36 ft.

Column 29 = col. 27 × 4 as in col. 22.

Column 32. To obtain this, the number of foot-pounds exerted per minute has been calculated from the average *pressure*, *area of piston*, *point of cut-off*, *length of stroke*, and *mean piston speed*, using cols. 19, 26 and 29 as data. The effective pressure during admission was first obtained by employing this formula, stated in *Engineering*, $p' = \frac{4}{5} p = \cdot 8\, p$. The absolute pressure during admission was then found by adding 14·7 lbs., and the terminal pressure, at the end of expansion, with the given cut-off, by dividing this by the ratio that the length of stroke bears to that of admission. Multiplying this by the hyperbolic log. + 1 of the latter, as previously illustrated, the mean absolute and effective pressures were obtained. The latter, multiplied by the area of the two pistons, and the datum in col. 29, gave the result in col. 32, and dividing this by 33,000, gave the *indicated* horse power in col. 33, or the total unbalanced power exerted to overcome the combined resistances of friction and that due to the load or weight of train.

To calculate the mean tractive power, in col. 31, I first obtained the tractive power *per lb. of effective pressure per sq. in. on the pistons* by means of the formula $t = \frac{d^2 \times S}{D} = \frac{16^2 \times 24 \text{ in.}}{62 \cdot 5} = 98 \cdot 944$ lbs. (S, being the length of stroke; d, the diameter of the piston; and D, that of the driving wheels in inches), and multiplied this result by the mean effective pressures previously obtained.

Column 34 = col. 15 ÷ col. 5 (cubic ft. per minute) × 62·4 (lbs. per minute) ÷ col. 33 (lbs. per H. P. per minute) × 60 (lbs. per H. P. per hour).

Column 35 = col. 12 ÷ col. 33 (lbs. per H. P. per minute) × 60 (lbs. per H. P. per hour).

Column 36 = col. 32 ÷ col. 12 × 100.

Train Resistance.—If we put the tractive power of 5671 lbs. that we have obtained $= R$, we have the condition of uniform motion. The tractive power must balance the resistances. If the total resistance, R, is more than T, the engine will not move, or, if already in motion, its motion will be retarded; if less, the motion will be accelerated. I will not enter here into the discussion of the subject of train resistance. The total resistance to traction is made up of internal resistance due to the friction of the axles, and external resistances. The former forms a constant factor in the total train resistance; the latter constitute a variable one which increases, as far as the laws governing them have been determined, as the square of the speed. The external resistances are: the rolling friction of the wheels on the rails, the resistance of cars on a straight and level track, the additional resistance, caused by gravity, on ascending grades, the resistance due to the friction of the engine, the resistance of curves, the resistance of the atmosphere, the wind, and that caused by the lateral play of the wheels and transverse oscillations of the engine and train. The conditions affecting these are: the condition of the engine, and of the permanent way, the straightness of the track, curves, grades, the weather and wind.

Perhaps there is no subject upon which engineering authorities differ more widely than upon the resistance of trains at different speeds. In fact, they have never been more than approximately determined, and the English formulæ which we have, do not represent the conditions upon American roads. The best formula for a straight and level track is based upon one of D. K. Clark's, however. The fact that he ascertained was that the resistance to a train at 60 miles per hour was 21 lbs. per ton of train. Hence for any other velocity we should have $R : R' = v^2 : v_1^2$, whence $R = \frac{R'}{v_1^2} v^2 = \frac{21}{v_1^2} v^2 = \frac{v^2}{171}$. The constant resistance for American cars Mr. Forney takes at 6 lbs. per ton, so that the resistance of this train would be represented by

$R = 6 + \frac{v^2}{171} = 6 + \frac{(30)^2}{171} = 6 + 5{\cdot}2 = 11{\cdot}2$ lbs. per ton, or, in all, $11{\cdot}2 \times 205$ tons $= 2296$ lbs.

In order to find the resistance of the engine and tender alone, the method given by Weissenborn's "Engineering" is to find the resistance of the locomotive as a carriage by means of the formula $R' = 6 + \frac{v^2}{240}$, which gives 9·7 lbs. per ton, or 494·7 lbs. total; and add to it what he calls the "machinery friction," which is estimated to follow the formula $F = \left(2 + \frac{v^2}{600}\right) \times \frac{W + w}{W}$, in which W is the weight of the engine and tender, and w, the gross weight of the train. This gives for the machinery friction,

$F = \left(2 + \frac{(30)^2}{600}\right) \times \frac{205}{51} = 3{\cdot}5 \times 4 = 14$ lbs. per ton, or, in all, $51 \times 14 = 714$ lbs. The resistance of the engine alone would therefore be $494{\cdot}7 + 714 = 1208{\cdot}7$ lbs. to be constantly overcome at 30 miles per hour.

(To be continued.)

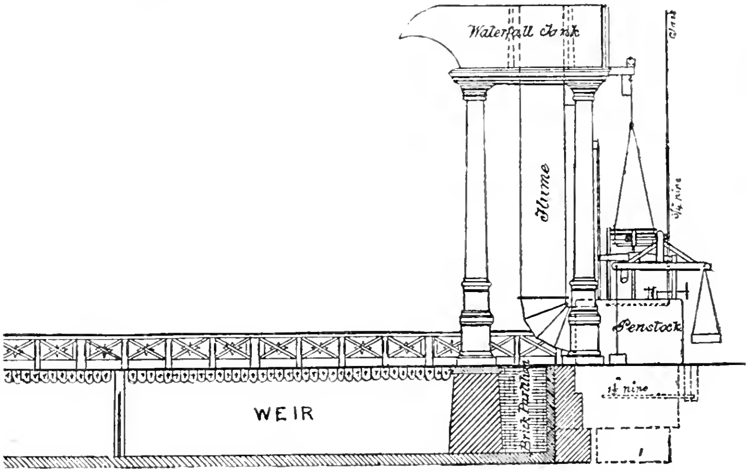
Furnace Bars.—The revolving furnace bars invented by Schmitz have been introduced in some of the London establishments, and give great satisfaction. In these the ordinary straight fine bars are replaced, singly or in pairs, by hollow cylindrical bars, pierced with holes, and so arranged as to be easily capable of revolution, and these bars rest on supports which are themselves cylindrical and hollow, being supported lengthwise by a plate beneath the door of the fire box, and fitting into a neck made at the near end of the bar. For revolving them a winch is inserted in the hexagonal opening in the front end of the bars, by which they are turned, in operation.

The lighting of the furnace, in this case, is performed in the ordinary way, and the furnace door can be kept completely closed; the perforations of the hollow bars supplying as much air as is necessary and to a much greater advantage, as it passes directly through the coal instead of playing on the top, and the combustion is much more uniform and thorough. At intervals the bar is turned partly around, and a clear surface free from slag is presented to the fuel. The ashes which fall through the perforations of the grate in this arrangement can be conveniently pushed out into the ash pit, thus avoiding the necessity of raking down.

TESTS OF TURBINE WATER-WHEELS AT THE CENTENNIAL EXHIBITION.[1]

The following extracts are taken from the report of Mr. Samuel Webber, Superintending Engineer of the Centennial turbine tests, to Mr. John S. Albert, Chief of the Bureau of Machinery.

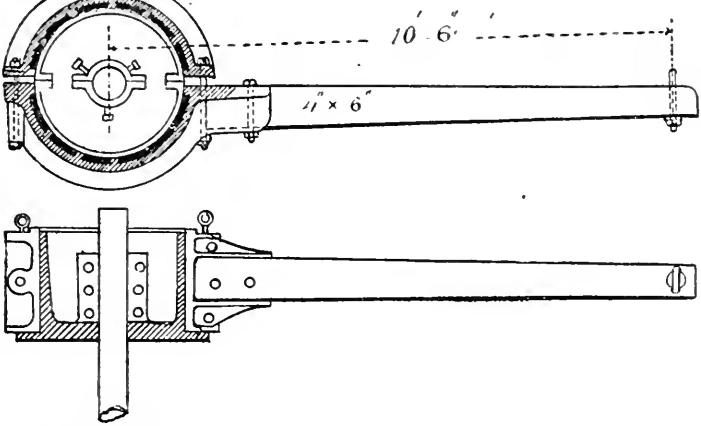
"The water was furnished by a pair of powerful centrifugal pumps, * * * which raised from 1800 to 1900 cubic feet of water per minute to a tank. placed at the end of the Hydraulic Annex, the overflow of which was 33 feet above the level of the water in the large tank in the centre of the building, from which it was pumped. This water usually formed the 'cataract,' which was stopped partially or wholly while testing the turbines.



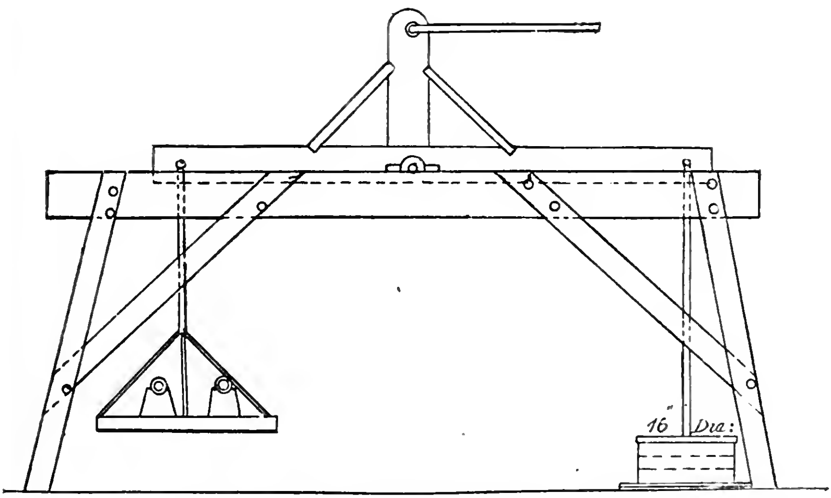
"From this tank a wrought iron tube or "penstock" 4 feet in diameter descended to the "flume," or case in which the wheels were set, and which was 8 feet in diameter by 6 feet in height, supported by a brick wall resting on a granite bedstone. From the wheels the water was conducted by an ample passage to a rack, or a strainer, 30 feet from the wheel, and stretching across a brick tail-race 14 feet wide by 8 deep, at the lower end of which, 15 feet below the rack, was the measuring weir, 9 feet long, formed of a heavy cast iron plate planed to a true edge $\frac{1}{8}$ of an inch thick, and beveled from that on the further side at an angle of 45°. The upright ends of the weir

[1] From advance proof sheets of the report of the Director General.

were made of Georgia pine, cut and beveled to the same dimensions, and were carefully adjusted.



Wheel 37.44'' diam., 18'' face, 1000 lbs. weight. Brake 1600 lbs. weight, leverage 132. 1.



BRAKE FOR TESTING TURBINE WHEELS.

"The hook gauge * * * was placed in a tight wooden box 6 feet up-stream from the weir, and the water was admitted to this box, for the purpose of measurement of height, by a few $\frac{3}{8}$ inch holes bored in the bottom of the box, 3 feet below the surface of the water; and an examination of the very thorough test of the Tait wheel shows

the sensitiveness with which the weir measurement responded to the changes of load and variation in the number of revolutions of the wheel.

"The apparatus for measuring the power consisted of a friction pulley fitted to the wheel shaft, 37·44 inches diameter and 18 inches face, which was clasped by a Prony-brake, consisting of a pair of cast iron shoes lined with wood, from one of which projected an oak arm 6 by 4 inches, through which a knife-edged eye-bolt was fastened at a distance from the centre of shaft of 10·50 feet, or the radius of a 66 feet circle. * * *

"To facilitate the handling of the weights, this lever was connected by an iron rod with the short arm of a bell-crank or scale beam 2 feet in height, while the longer arms, which were attached to the scale, pan, and regulator, were 4 feet each, thus giving a leverage of 132 to 1 for each pound placed in the scale. All the pivots or bearings of this scale-beam were of steel, knife-edged and bearing in hardened iron sockets.

"The pulley, weighing 1000 pounds, rested on the shaft and step of the wheel, corresponding in some measure to the usual "crown gear," but the brake, which weighed 1600 pounds, was suspended by a swivel from a beam directly over the centre of the wheels, so as to allow perfect freedom of motion in any direction. An examination of the records will also show the sensitiveness and accuracy of this part of the apparatus, every distance and dimension of which I carefully measured and adjusted personally before commencing the tests.

"The head of water acting on the wheels was ascertained by a gauge-rod, having a hook at the lower end, which was carefully kept at the level of the tail-water in a box sunk in the floor and connected with the tail-race by a perforated pipe; while a pipe led from the case to the level of the head water, where a glass tube enabled the observer to read at once the acting head, by the graduations on the upper end of the gauge rod.

"Experiments not strictly belonging to the wheel tests were made, showing that the same wheel, with the same load, at different times repeated the number of revolutions very accurately, and proved the correctness of the apparatus. The revolutions of the wheel were ascertained by a worm-gear clock, which was thrown in and out of connection with the shaft of the wheel, at signals given by a bell, which was struck at intervals of 1 or 2 minutes, according to the length of test desired.

"The friction pulley was accurately balanced before commencing the tests, and, when the wheels themselves were truly set, ran with perfect steadiness and regularity.

"Each exhibitor was allowed free access and liberty of observations during the tests of his own wheel; and, whatever may be the accuracy of the net results obtained, the comparative ones may be depended on, as the tests were all made under similar circumstances, and the different points watched and the notes taken throughout by the same observers, none of them having any interest whatever in the result, or any opportunity at the time of knowing what the observations were at other stations than their own.

"It is worthy of notice that the best results have been attained by wheels taken just as they came from the shop, without any especial finish or preparation, and the thoroughly exhaustive test of the Tait wheel is worth studying, as showing the accurate working of the apparatus.

"The Geyelin wheel, entered by R. D. Wood & Co., was so tightly fitted in the shop that I do not think we got a fair record of its power; and the Cope wheel used so much water that we could not carry the test out in full, but the percentage was gaining regularly up to the last trial, when we exhausted the supply of water, having reached over 1860 cubic feet, or about 14,000 gallons, per minute.

"The Hunt wheel also taxed the supply of water to the utmost. The Tyler wheel was too loose in the upper bearing on the second trial, and the third wheel, from the York Co., was only tested to prove or disprove what was believed to be an unsound principle, viz., that of shallow buckets and central discharge; and the result is confirmed by those obtained from some of the other wheels.

"The leakage of the flume was large during the first 6 trials, but by caulking and tamping with lead was very much reduced at the test of the Tyler wheel, after which test the allowance was uniform of 14,352 cubic feet per minute waste to each wheel. In the first 6 tests it was taken as noted in the tables, and the amount is in all cases deducted from the water consumed per minute."

Accompanying the report are full tables of the data obtained and the results as calculated therefrom. As it is impracticable to reproduce these tables entire, the one given herewith is constructed from them, and gives the percentage of useful effect of the various wheels. The head of water under which the tests were made, varied but a few inches either way from 31 feet.

TEST OF TURBINE WATER-WHEELS AT THE CENTENNIAL EXHIBITION.

NAME AND ADDRESS.	Diameter of Wheel.	Percentage of Effect.								
		Full Gate.			$\frac{3}{4}$ Gate.			$\frac{1}{2}$ Gate.		
		Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
Barber & Harris, Meaford, Canada,	20 in.	76·08	67·85	73·43	71·30	66·09	68·69	71·77	48·70	60·23
i T. H. Risdon & Co., Mount Holly, N. J.,	30 "	87·68	85·44	86·55	82·41	81·12	81·76	75·35	73·16	74·54
Knowlton & Dolan, Logansport, Ind.,	24 "	77·43	76·22	76·67	....	....	....	62·73	61·94	62·23
ii A. N. Wolf, Allentown, Pa.,	24 "	74·80	70·91	72·97	74·00	69·10	71·39	64·90	61·48	63·22
iii John T. Noyes & Sons, Buffalo, N. Y.,	24 "	65·66	61·23	62·79	61·27	58·40	59·97	52·52	50·05	51·34
Goldie & McCullough, Galt, Canada,	27 "	82·20	73·30	78·27	71·93	70·00	70·96	60·50	56·70	58 10
iv Putnam Machine Co., Fitchburg, Mass.,	30 "	79·55	75·27	77·31	79·85	70·24	73·66	67·10	66 00	66·55
Wm. F. Masser, Allentown, Pa.,	24 "	75·09	72·68	74·12	....	....	....	65·80	63·80	65·11
v York Manufacturing Co., York, Pa.,	27 "	73·60	63·60	69·60	67·45	66·56	67·00	67·50	65·90	66·70
National Water-Wheel Co., Bristol, Conn.,	25 "	83·70	75·80	80·70	70·50	67·30	68·90	....	....	....
E. T. Cope & Sons, West Chester, Pa.,	30 "	78·70	66·70	70·00	....	....	....	....	....	....
vi Thomas Tait, Rochester, N. Y.,	25 "	82·03	73·60	79·28	72·60	69·60	70·80	66·20	65·00	65.43
vii R. D. Wood & Co., Philadelphia, Geyelin Duplex,	36 "	77·40	75·60	76·74	....	....	....	....	....	....
" Single,	36 "	83·30	76·80	79·41	....	....	....	....	....	....
Chase Manufacturing Co., Orange, Mass.,	24 "	68·30	60·20	62·99	67·60	62·10	65·74	57.30	55·70	56·60
viii Rodney Hunt, Orange, Mass.,	24 "	78·70	76·60	77·95	71·40	71·00	71·22	68·72	68·38	68·56
Stout, Mills & Temple, Dayton, Ohio,	30 "	68·40	66·60	67·50	....	....	....	69·13	62·80	66·55

NOTES TO TABLE.

[i] A note accompanying the record says: "A full gate test at 280 revolutions per minute showed a better apparent result than either of the above, but is omitted from a little uncertainty as to the weir reading. The power attained was 85·42 P."

[ii] Two tests were made of this wheel and the mean result is given. There is a difference of 1·88 per cent. in favor of the second test with full gate, and of 3·36 per cent. in favor of first test at half gate.

[iii] The test at full gate was extended into the second day with better results than on the first day. The mean of both is given.

[iv] Two tests were made, of which the first and best is given. In the second test the "upper bearing of shaft loosened."

[v] There were three wheels from this firm tested, the second of which is given, it also being illustrated in the report. The first one was 26¼″ diam., and at full gate gave the same percentage of effect within a small fraction, but at three-quarters and half gate gave 62·90 and 59·95 per cent. respectively. The third wheel was 27″ diam., centre vent, and gave low results.

[vi] This wheel was tested with as little as one-eighth gate, and developed 16·85 H. P. and 35·20 per cent. of effect.

[vii] Three tests were made with the Duplex wheel, the first and best being given. Notes accompanying the record indicate that the wheel bound in the case and step. The single wheel also bound in the step.

[viii] Note says: "Very difficult to supply water at full gate. Head ran down several times and tests were rejected." K.

Hot Air Signal Pipes.—M. Montenat has experimented with copper tubes, containing red-hot network or little furnaces of glowing coals, by which he produces sounds of a great intensity, the musical note being modified by the position of the heat in the tube and by the length of the tube itself. He would like to construct, for the Exposition of 1878, a large apparatus on this principle, to produce sounds which can be heard at great distances. He believes that fog signals of such a character would have many advantages over those which have hitherto been used.—*Société d'Encouragement pour l'Industrie Nationale*, Jan. 12, 1877; *Les Mondes*, Feb. 15, 1877. C.

Street Tramways.—At the meeting of the Society of Arts, London, held February 7th, 1877, Capt. Douglas Galton, C.B., F.R.S., etc., read a paper[1] on street tramways, in which he gave much valuable information relative to the comparative cost of horse and of mechanical traction on such roads.

The paper discusses motive power by steel springs, ammonia, superheated water and compressed air, but gives no estimate of cost of these, except in the Scott-Moncrieff compressed air street car, which the inventor claims to be able to run for 2·997*d.* per car mile.

Of the steam street cars in use in England, those given as the most successful are the Merriweather, which is a separate locomotive drawing the usual cars, and the Granthan steam car, carrying its own motive power; preference seems to be given to the latter. Both of these have been made to comply with the somewhat stringent regulations of the Board of Trade.

The cost of traction per car holding 44 persons, drawn by two horses, on the Bois de la Chambre tram road at Brussels, having gradients of 1 in 33, and an incline nearly 1¼ miles long of 1 in 100, is given as follows:

Cost of Stabling, 10 horses,		per day,	£0	02	0.
" Food,	" 2*s.* 1*d.*	"	1	00	10.
" Harness, etc.,	" 10*d.*	"		08	4.
Sinking fund for Horses @ 20 per cent. on £375, per day,	.	.	.	4	1½.
Total cost per car per day,			£1	15	3½.

The horses travel a total of nearly 16 miles each.

The cost of steam traction on the same road including 5 per cent. interest on engine, and 10 per cent. for repairs and sinking fund, is 18*s.* 3*d.* per day.

On the Wantage tramway, which is 2½ miles long and has a gradient of 1 in 50 for 350 yards, and several sharp curves, the cost of working the Granthan steam cars is 17*s.* 6*d.* per day, or 5½*d.* per mile, against 27*s.* 6*d.* per day, or 8½*d.* per mile when worked by horses.

In the discussion which followed the reading of the paper, it was claimed that in Paris where 30 of the Merriweather steam tram cars are running, that they are run at a cost of 48 francs per day of 16 hours, and that they can be run in England at a cost of 3*d.* per mile against 7*d.*, the cheapest rate by horse power. K.

[1] *Journal of Society of Arts*, February 9th, 1877.

STREET PAVEMENTS.

[Contribution from the Department of Civil Engineering, Towne Scientific School, University of Penna.]

By Prof. LEWIS M. HAUPT.

Since the days of MacNeill, Telford, McAdam, Parnell and others, volumes have been written upon this subject, yet we have in many localities pavements which are a disgrace to a community making any pretentions to scientific knowledge.

This results either from a misunderstanding of all the conditions of the problem or an inability to fulfil them. The conditions, it is true, are intricate and variable, depending on location, grades, nature of merchandise, vehicles, power, subsoil, finances, etc., but in this monograph we propose to discuss briefly only the requirements of the *surface covering*, and to determine in the light of a long and varied experience what material will best fulfil all the conditions of a crowded thoroughfare.

The requirements of the surface are that it shall be: (1) firm and elastic; (2) noiseless, clean and dry; (3) smooth, yet rough; (4) permanent, yet easily removable; (5) light, yet heavy; (6) it should be durable, producing a minimum amount of wear and tear; (7) it must also be cheap and readily obtainable, and (8) non-combustible.

The impossibility of selecting any one of the available materials, wood, stone, brick, cement, iron, or asphalt, which will fulfil all the above conditions, is apparent. A compromise must therefore be made, and one or more selected which will approximate most nearly to the requirements of the case.

It is interesting to observe the ingenuity displayed by advocates of a particular material, in making it conform to every want, and in *theory* all of the above materials have been found to answer equally well, but from a practical, rational and disinterested point of view it is impossible that such should be the case; *e. g.*:—

Vegetable Substances, containing within themselves nitrogenous principles, elements of decay and putrefaction, should be rejected from sanitary considerations alone, but in addition to this their combustibility, softness of fibre, permeability and cost, are serious obstacles, and the experience of numerous trials on both continents, under varied

conditions, has proved them failures as to durability. We feel entirely justified, therefore, in omitting this material from the list of available substances until some more efficient means be successfully introduced of preserving the blocks, draining the foundation and preventing dry rot.

Iron has been used in various forms, but being a manufactured article, it is more expensive than stone or wood which are natural products. Hexagonal and other forms of blocks, covered with studs, and standing on legs which were driven into the foundation, have been discarded because of the noise, expense and insufficient foothold. Wherever tried in the form of blocks, iron has been found very objectionable, and its use is now restricted to tram and railroads.

Bitumen is a natural mineral product, belonging to the class of hydrocarbons, and may be found either solid, as in *asphaltum*, or liquid, as in mineral tar. It is used chiefly as a matrix for harder materials.

The best asphaltum is imported from Seyssel, in France, and Neufchâtel, Switzerland, but a tolerably good article is also obtained from the island of Trinidad. This substance melts at a comparatively low temperature, and is quite brittle when cold, so that it possesses properties which render it inappropriate for roads when subjected to great ranges of temperature and heavy traffic. When used, however, with sand and cement it forms an excellent suface, so far as smoothness and durability are concerned.

The wooden pavement on Pennsylvania Avenue, Washington, has recently been replaced by another, part of which is composed of Neufchâtel bituminous limestone, one and three-quarters inches thick, laid on a foundation of eight inches of cement, and the remainder of "Grahamite" (pure asphalt from Ritchie County, Va.), two and a half inches thick, on a similar foundation.[1]

Brick, being merely clay indurated by burning, is too brittle for ordinary travel. We find ourselves, therefore, restricted to the use of stone or cement as fulfilling most nearly the requirements of a good road covering.

But *Stone* occurs in a variety of forms, as in "cobbles," boulders, "spalls," or blocks, and in sizes which vary as the ratios of their three dimensions. Of the three first mentioned forms it is difficult to decide

[1] Letter of Gen'l Q. A. Gillmore, and his work on Roads and Street Pavements, page 182.

which is most injurious, yet these are the favorites with the community, because of their cheapness (?), and with the contractors, because of the proportionately large margin of profit, and necessity of frequent repairs. By this general and brief analysis we are induced to believe that stone of a regular geometrical form is that which is most suitable for the purpose; cement being an artificial monolith, whose dimensions may be extended at pleasure, is included in this class. It is not intended to review in detail the whole question of the adaptability of the various materials to the object in view, as this has already been done in an exhaustive and able report of forty-one pages, made by eight eminent engineers,[i] and published in the JOURNAL of September, 1843, but to review and emphasize the conclusions therein deduced. It was recommended to use a pavement of "dressed stone," laid diagonally upon a foundation of concrete, in those squares where the sewers and various supply pipes were completed, and to lay stone tramways on the steep gradients from Front Street down to Delaware Avenue. These are substantially the conclusions we are forced to adopt, even after the lapse of these thirty-four years, yet in all this time they seem to have gained but little ground.

A tramway in connection with a "Belgian" block system would fulfil all the requirements in the best and most economical manner. Trams, eight inches deep, and two feet wide, if well laid, would oppose the least possible resistance to the wheels of vehicles, and would be noiseless, whilst the blocks between would furnish the desired foothold, and the clicking of the horse's feet give sufficient warning of the approaching vehicle.[ii] This arrangement supposes the conditions of the horse and carriage to remain constant, and until lately it has been assumed that these elements of the problem were fixed, but rubber tires have been introduced and give great satisfaction. Still the roughness of the pavement required to furnish the necessary foothold has been found

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[i] The members of this committee appointed by the Franklin Institute June 26th, 1843, to report to City Councils on "The best modes of paving highways," were:

Elwood Morris.	George W. Smith, deceased.
Jno. C. Trautwine.	Jos. Saxton.
Henry R. Campbell.	M. T. W. Chandler, deceased.
Solomon W. Roberts.	Sam'l V. Merrick, deceased.

[ii] Tram stones of the above dimensions can be furnished and laid, of Old Dominion granite, at a cost of $3.25 per lineal yard, whilst Belgian blocks, covering the same surface, are worth $2.25, making the trams cost one dollar more per yard, but every other consideration is in their favor, and ultimately they are cheaper.

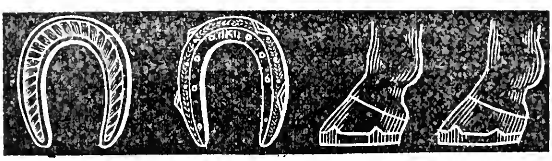
to cut and destroy them so rapidly as to render their general introduction improbable. If now we can substitute for the present shoe a material that will prove as durable and as secure, at the same cost, it will open the way to great reforms in all the elements of locomotion, viz. :—the pavement, the vehicle and the power.

Such an improvement has indeed been made and tested satisfactorily. It consists of a hollow shoe of the ordinary shape, open at the bottom, and having iron studs projecting vertically downwards through a three-quarter inch tarred rope which they hold in place, and which serves as a packing. The shoe is put on without heating and held in place by six nails. It has been used until worn down to a knife edge, and its life is quite as long as that of the ordinary iron shoe. The rope is not kicked out by use, but is in fact riveted firmer by the pounding down of the studs.[1]

The general introduction of such an improvement would undoubtedly lead to the substitution of concrete for the rumbling rubble pavements now in use. The chief objection, lack of sufficient foothold, having been overcome, minor difficulties need have but little weight, as that portion of the surface overlying sewers, etc., might be divided into blocks which could be readily removed and replaced. The necessity of breaking the surface for pipes could easily be avoided by laying them hereafter under the sidewalks or in rear of the dwellings, in streets of the second class.

There *is* a street in Philadelphia (a short one to be sure), upon which there is no railway, and whenever a wagon or cart passes at a trot it shakes all of the buildings, which are said to be substantial. What must be the waste of energy that will set in vibration the houses on both

[1] The sketch below indicates the outline of this shoe. It is cast of malleable iron, of the usual shape of a horse-shoe, having its lower face open, into which a slip of tarred rope is pressed of larger diameter than the width of the opening; a range of prongs rises in the centre of the cavity which pierce the rope, and thus uniting with the stress from the sides, hold the hemp firmly. The shoe partakes somewhat of the moccasin and also of the sandal; it absorbs concussion and retains friction, and embraces conditions of fitness such as I never saw associated before.—H. O.



Under surface. Upper surface. Shoes in position.

sides of a street whenever a vehicle passes? Yet the injury is not limited to the vehicle, the edifice, nor the road covering, all of which are badly shaken up, but extends in a greater degree to the animal life affected by it: the horse, and the individuals in the house or conveyance. It is a constant strain upon the nervous system of women, invalids and children whose sleep is disturbed and restless. The racket is especially noticeable by visitors from rural districts, who are unaccustomed to such a continual jarring. This enormous waste of energy can and should be avoided by recourse to proper engineering expedients, and no one will deny that a uniformly smooth, even and continuous surface, such as that furnished by a good cement pavement, with only joints enough to permit of expansion, would fulfil in the most perfect manner all the requirements for the horse, carriage, passenger and resident, could be kept perfectly clean, and when once laid would require the minimun amount of expense for repairs and police.

Before closing there is another point which is worthy the consideration of the enterprising and progressive citizen, and that is the large amount of space wasted by front steps. In many streets at least half the footwalks are interrupted by such projections, forming useless dead spaces between them which serve to collect the snows of winter, to be piled up in the street, forming impassable obstructions for a considerable length of time. The steps themselves, exposed as they are, become dangerous from ice, and are not an architectural necessity nor ornament. Every consideration of humanity would suggest their being withdrawn, and, when necessary, occupying the place of the vestibule, leaving an open recess or niche in the place of the outer door. Thus the visitor or resident would be sheltered from sun, wind, rain or snow whilst waiting the answer to his summons; the steps would not be dangerous by being coated with sleet; the suggestion of hospitality would be extended by the apparently open door, which effect would be heightened by an outside lamp at night, and the full breadth of the sidewalk left available for a promenade, with rows of trees, if desired. The plan is not a new one, but is in use in many cities of this country and the continent.

Carbon for Electric Light.—M. Th. du Moncel forms a compressed mass of carbon and magnesia, which is very hard and burns without ash, giving a light which is steadier and 34 per cent. more intense than that of gas carbon.—*Ex.* C.

Chemistry, Physics, Technology, etc.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS, DURING THE LAST TEN YEARS.[1]

By Dr. A. W. Hofmann.

From the *Chemical News.*

[Continued from Vol. ciii, page 274.]

The Belgian pyrites kilns have generally fixed grates. Beneath them is a large channel connected with the chimney. Before introducing a fresh charge of ore the workmen go into the channel and remove the exhausted ore which lies upon the grates with long iron hooks. Not to be inconvenienced by dust during this operation they open the damper which connects the channel with the chimney, so that fresh air rushes to them in plenty. This arrangement affords at the same time a further advantage. If the access of air to the furnace could be hermetically closed it would be possible to hinder the escape of sulphurous acid when the doors are opened for the introduction of a fresh charge. But as hermetic closing is not practicable in kilns the loss may be avoided with the aid of the long channel. The outer door leading into the channel is closed as tightly as possible, and the damper leading to the chimney is opened just so wide that the air which enters the channel through the imperfect joints of the door passes beneath the grate bars into the chimney, and not up between the bars into the kilns. Too strong a draft would draw air down through the upper or working doors into the kilns, and consequently sulphurous acid would escape from the chimney. The combustion is therefore at a standstill till the new charge is spread out in the kilns; then the damper is closed, and the door leading into the channel is opened as far as the proper working of the kilns requires.

In France movable furnace-bars have been used in the pyrites kilns for some sime. They were, indeed, already known in 1848. They

[1] "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

are convenient for the workmen, and afford besides the advantage in roasting, that on moving the bars backwards and forwards, only the lowest stratum of the charge falls out. The compartments are mostly separated from each other by arches; the kilns resemble the English pattern, but the stratum of ore is shallower, as for the most part richer, more combustible pyrites are employed.

In Germany kilns for lump pyrites are in use, of the French, the Belgian, and the English kind. A combination of the French and the Belgian kiln was introduced in 1866 in the "Rhenania" chemical works, near Stolberg, and this construction has since been more extensively adopted. The burnt ores are removed by means of revolving bars, because, on the Belgian method workmen often penetrate with their long hooks into layers still rich in sulphur, and thus the burnt ores show too high a percentage. In the "Rhenania" the long Belgian channel beneath the grates has been retained, permitting the introduction of a fresh charge without loss of sulphurous acid. It further permits the introduction of a wagon beneath the kilns, into which the spent ore falls at once and can be removed without the trouble of loading.

If the slope of the ground permits no other arrangement, the wagons may have a low shape, and the tramway may be on the same level as the floor of the furnace. At the Rhenania and in other places where the pyrites can be brought up on to the kilns without difficulty, the charge of lump-ore is introduced through an aperture in the vault, and the process does not take more than 20 secs. If it is too difficult to convey the ore upon the top of the kilns, it is thrown in with shovels through the working door. In this manner 400 kilos. can be introduced in five minutes. As charging always disturbs the progress of the furnace, it is advisable to restrict it to a minimum of time.

Poor lump-ores are roasted in Freiberg and Oker in small shaft furnaces with a lateral exit for the gases, and a low vault in which a high layer of ore is constantly maintained.[1]

As for the roasting of smalls and rough fragments, it is sometimes carried on along with the lump-ores. This method is not advantageous, and renders the burning of the whole of the pyrites imperfect.

It is better to work up the smalls into balls (Klütten, Stöckeln, *Boulets*).

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[1] Compare Graham-Otto's *Lehrbuch*, Band 2, abth. 1, 549.

For this purpose they are mixed with more or less clay and water, and moulded into balls or cut in pieces. The dried balls are then burnt either alone, or mixed with lump-ores in the kilns described above. English establishments which burn Spanish cupriferous pyrites mix the finely ground ore with water, without clay, and mould the paste into balls, which hold together owing to the presence of vitriol.

For roasting smalls and coarse powder several kilns have been latterly proposed.

In 1862 the so-called shooting-kilns were introduced at Freiberg, their original and ingenious construction being due to Moritz Gerstenhöfer. They have been described in most technological journals, and in Schwarzenberg's "Treatise on the Manufacture of Sulphuric Acid" (p. 415), they are represented in figures drawn to scale. F. Bode, assistant in Gerstenhöfer's technical office, describes them in detail in his pamphlet "Contributions to the Theory and Practice of the Manufacture of Sulphuric Acid."[1] He deals at length with all the objections to Gerstenhöfer's furnaces, and endeavors to refute them.

The ores to be burnt in Gerstenhöfer's kilns must first be ground to a fine powder. They are desulphurized whilst falling from a shaft of about 5 metres high, 1·25 metres wide, and 0·8 metre deep. This shaft is fitted up with three-sided prisms of fire-clay, arranged with one angle downwards and one side upwards so that intervals remain between them, and the particles of ore fall from one prism to the next. The raw ore is introduced continuously by means of a hopper, and the burnt residue is withdrawn from time to time below. The furnace is heated with wood and coal previously to entering the ores, and as soon as they are introduced the fire is withdrawn, as the cumbustion of the sulphur keeps up the necessary temperature. Rich ores are passed through the kilns in small quantities and poor ores more rapidly.

Instead of putting in furnace bars below and removing them again when the kiln is warm, the author introduced a permanent lateral fire in the Gerstenhöfer kilns built at Stolberg, which was ready for use on a change of ores or any interruption of the process. In Stolberg the burnt ore, also, was drawn at once out of the furnace into a truck, introduced below the bottom sliding plate. Both these arrangements were considered by Bode as improvements.

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[1] "Beiträge zur Theorie und Praxis der Schwefel Säure Fabrikation."

Gerstenhöfer's kilns afford the great advantage that poor ores may be burnt without the aid of fuel, so as to produce rich gases of a constant composition and fit for the chambers. If perfect burning is not required they are unequaled. At Vedrin, in Belgium, where the good pyrites are sold and only the inferior qualities are used for the preparation of acid, satisfactory results are obtained with them, as in Freiberg, where a mere preliminary roasting of mixed ores is required.

For roasting rich smalls this furnace has not come into general use, and is employed neither in France nor in England (except for copper ore at Swansea). It has been abandoned at the chemical works at Chauny (Dep. Aisne), of Widnes (Lancashire), of Nienburg on the Weser, and of Stolberg, on account of imperfect burning and excessive production of flue-dust.

A furnace for smalls invented by Perret was shown as a model at the Paris Exhibition of 1867, and has been fully described by Schwarzenberg,[1] This furnace consists of several stages of horizontal plates arranged above a kiln for lump pyrites. These plates are fixed at intervals of 30 centimetres, and are covered with smalls to the depth of 5 to 8 centimetres. The hot gases from the kilns below sweep over them whilst ascending, and exhaust them of sulphur. Perret's furnace has been in action for years in the Wohlgelegen Chemical Works, near Mannheim, but otherwise it has remained confined to France. As originally designed, it rose to the height of 6 metres above the furnace, and required much labor, as the ores had to be pushed up from stage to stage, whereby also some sulphurous acid escaped. The most recent Perret furnaces are essentially modified and act very satisfactorily. They are a little above 2 metres in height, and have only four ranks of plates, which can all be charged from the level of the furnace. The ore burns clean on every plate, and does not require to be pushed up from below. In this manner equal weights of lump and smalls are burnt.

Maletras, of Rouen, set up a plate furnace on Perret's principle, in which rich smalls are thoroughly roasted alone without lumps, and without the aid of coal. Similar kilns are in use at Dieuze and near Berlin. The roasting of poor smalls at Dieuze has proved unsatisfactory, although the ore was dried before charging the furnace.

[1] Bolley, "Handbuch der Chem. Technologie," ii, 421.

Smalls of 46 to 48 per cent. of sulphur were burnt down to 3 or 4 per cent.

In 1861 Peter Spence patented a furnace in England[i] similar to those which had been in use for twenty years in Belgium, and at Stolberg, near Aachen. The furnace was worked with fuel, which heated a muffle, constructed of arches, for the reception of the ores. Much air entered through the working doors, so that the gases contained but little sulphurous acid. A kiln of this kind is still in use at the works at Imeary, near Newcastle-on-Tyne. In Spence's establishment it has fallen into disuse, and has altogether found but a very limited application.

Allhusen, of Gateshead, burns smalls on iron plates above the lump pyrites. Nothing has transpired concerning the working of the process.

The "Rhenania" Chemical Works of Aachen exhibited at Vienna, in 1873, models of the kilns which were first constructed at Stolberg, on the principle of Wilhelm Helbig and the author.[ii] These kilns serve for burning finely powdered sulphur ores, and especially for iron-pyrites and zinc-blende. The peculiarity in the construction is that the ores are roasted upon strongly inclined planes, down which the pulverulent mass slides when a portion of ore is taken away from below.

The plate furnace described in 1870 is in extensive use for burning the smalls resulting from breaking up the ores, and is at present being set up in several manufactories. It is charged with a mixture of coarser and finer fragments, sand-ore, and meal-ore. The lumps are burnt in the ordinary manner close by the plate tower, and the hot gases escaping, sweep over the plates and burn the smalls. The ore passes over the plates in the form of a continuous stream, the thickness of which is determined by the interval between two plates. Green ore is added and burnt ore withdrawn without interrupting the process. The upper aperture is kept covered with a heap of ore, so that as it slides down no sulphurous acid can escape at the hopper. At the lower part of the furnace the burnt stratum of pyrites is removed by means of a roller, which revolves automatically every five minutes, and is driven by a small water-wheel. Paul Seybel, of

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i A. D., 1861. Specification No. 3002.

ii *Zeitschr. d. Ver. Deutsch. Ingen.*, 1870, p. 705, and 1872, p. 505.

Liesing, near Vienna, works the kiln intermittingly, withdrawing about 200 kilos. of burnt ore every six hours by turning the roller. As smalls in very fine powder do not slide down well, Seybel's method is preferable for such ores. At Liesing, ores from Bösing, in Hungary, are burnt in plate kilns down to about 4 per cent., and Styrian ores down to about 7 or 8 per cent. The burnt lumps of the latter kind retain 5 to 6 per cent of sulphur, whilst lump ores from Bösing burn down to 2 per cent.

Burnt smalls from the "Sicilia" mine, near Siegen, retain 4 to 5 per cent. of sulphur according to the size of the furnace and the quantity of ore passed through it. The burnt lumps which have been roasted along with smalls retain 5 per cent. of sulphur, whilst clean lumps burn down to 2 per cent. There is therefore a decided improvement in roasting these kinds separately.

The before mentioned plate-furnaces give in most cases very satisfactory results.

At Oker in the Harz, a plate-furnace was built for hammer dust, poor in copper but rich in sulphur, such as the Rammelsberg yields in quantity. The operations carried on were changed in the meantime, and when the structure was complete it was no longer found desirable to burn the ores in the plate-furnace for which it was intended. It was charged with ores rich in copper, the burning was not satisfactory, and the furnace was removed.

Hitherto only one plate-furnace has been built behind each kiln for lump pyrites, instead of arranging a system of plates above each compartment of the kiln, as in Perret's furnace.

For the utilization of the hammer dust from lump pyrites, a tower suffices, as given in detail in the plans published, capable of burning every twenty-four hours 600 to 1000 kilos. of ore, the granules being from 1 to 12 millimetres in diameter. Other combinations would permit a richer charge, and such will doubtless be built.

The construction described in the journal above cited (1872, p. 505) will be further considered when we treat of roasting blende. This furnace requires the maintenance of a separate fire to keep up the heat, and is only to be recommended where coal and smalls are cheap.

Experienced technologists have proposed furnaces with inclined plates, in which smalls may be burnt without the action of lump pyrites and without especial firing, as in the furnace of Maletras. Where rich pyrites are accessible, such arrangements may prove advantageous, but we have no experience as to their action.

Determination of Sulphur in Pyrites.—The determination of the sulphur in the burnt ores is generally effected as follows:—The finely powdered ore is heated in a flask with a mixture of 2 parts nitric acid and 1 part hydrochloric, evaporated to dryness, and again treated with hydrochloric acid to expel any nitric acid. The sulphates are then dissolved by treating the residue with hydrochloric acid and water, filtered, and the sulphuric acid in the filtrate is determined by means of chloride of barium. Chemists have made many attempts to place a more expeditious method in the hands of the manufacturer.

In 1861, Pelouze[i] published a process in which the ores are treated with chlorate of potassa and a weighed quantity of pure carbonate of soda in a platinum crucible. The melted mass is dissolved in water, and the excess of soda is determined volumetrically by saturation with a standard acid. Barreswill called attention to a source of error in this process in case of the presence of arsenical compounds in the ore. Bottomley and Bocheroff also pointed out its inaccuracy. J. Kolb[ii] made some interesting comparative experiments between the determination of sulphur by the above mentioned gravimetric process and the volumetric method of Pelouze. The results differed by several per cents. Kolb found that the source of error consisted, on the one hand, in the formation of silicate of soda, and, on the other, in the decomposition of chlorate of potassa in presence of oxide of iron into chlorine, oxygen, and caustic potassa. Kolb proposes to fuse the finely powdered ore along with 5 grms. soda and 50 grms. oxide of copper at a dull red heat; to treat the melted mass with hot water, to filter, and determine the excess of soda in the filtrate volumetrically.

In the Freiberg works[iii] 1 grm. of finely ground ore is mixed with 3 grms. anhydrous carbonate of soda and an equal weight of saltpetre. This mixture is placed in an iron crucible melted in a muffle at a red heat, the mass is dissolved in hot water, and the liquid is filtered into a beaker, in which there is a little hydrochloric acid to saturate the excess of soda. The liquid, which should have an acid reaction, is then boiled for a short time, and the sulphuric acid is determined volumetrically with a solution of chloride of barium, standardized, so that 1 c. c. indicates 2 per cent. of sulphur.

[To be continued.]

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i Pelouze, *Ann. Chim. Phys.*, 3, 63.

ii J. Kolb, "Notes sur l'essai des Pyrites," 1869.

iii Schwarzenberg, *opus citat.*, p. 424.

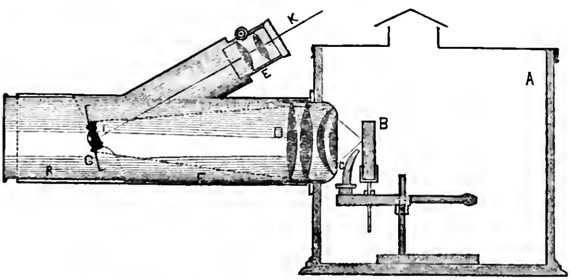
A NEW FORM OF MEGASCOPE.

By J. B. Knight.

The projection on the screen of the images of small opaque objects is often a very desirable means of illustrating lectures or papers read before societies, but has not been very largely employed, because of some difficulties attending its use.

As the light for forming the image is only that emanating or reflected from the surface of the object, it is important that it be strongly illuminated. The arrangement about to be described, was devised to secure a better illumination than is obtained with the ordinary megascope, and at the same time save the cost of a special instrument, by utilizing the ordinary projecting lantern with which nearly all our educational institutions are provided.

The arrangement for accomplishing this purpose is shown in the accompanying cut, in which *A* represents the lantern box; *B*, the lime; *C*, the oxy-hydrogen gas jet; and *D*, the condenser;—all of



the ordinary constituents. *F* represents a tube of sheet metal, of the proper size, to fit snugly over the ring of the condenser, and of sufficient length to reach considerably beyond the focus of the beam of light from it. The object *I* is held, by the stage *G*, in the beam of light as near its focus as possible, and yet give the proper breadth of illumination. This stage *G* is supported by, and hinged across its centre to, the inner movable tube *R*. To the tube *F* is attached a branch for holding the focussing lens at the proper distance from the illuminated side of the object, with its axis at as small an angle from the axis of the condenser, as will permit the cone of light passing from it to the screen to clear the top or sides of the lantern box.

Objects are easily placed on the stage *G*, by withdrawing the inner tube *R*, and are easily adjusted by this longitudinal movement, and the angular movement of the stage on its hinges.

This attachment is simple and inexpensive, and by it the usefulness of the projecting lantern is greatly increased.

What shall be done with the old rails?—The rapid increase in the manufacture of Bessemer steel, and the great reduction in the cost of production, have enabled our railroad corporations to substitute steel for iron rails, on very favorable terms. In order to make the substitution, the railroad officials desire to sell their old rails, and in order to secure orders, the manufacturers are often induced to yield imprudently to that desire, by accepting too large an amount of old stock in exchange for the new. M. G. Bresson[1] supposes a proposition to be made in the following terms:

"I need 10,000 tons of steel rails for the maintenance of my track, and I will give you in exchange 10,000 tons of iron rails. What will you charge to work them over?"

In seeking for a proper answer to the question, M. Bresson considers the injurious properties of copper, silicium, sulphur and phosphorus, and shows that a single ton of iron rails usually contains impurities enough to ruin several tons of Bessemer metal. Some of the impurities can be partially eliminated by known processes, but he thinks that a reasonable degree of prudence would require a reply, nearly as follows:

"I will subject your rails to proper analyses, and such as contain less than 0·2 per cent. of phosphorus, I will accept at the market price of old iron rails, delivering new steel rails in return, also at the market price. As to those which contain a larger proportion of phosphorus, I will re-roll these as iron rails, or, if you wish nothing but steel, I will fill your order with Bessemer rails, made of good materials. But I cannot take your bad rails, except at the price of my worst metal, for I must run the risk of keeping them for years in my inventory, and perhaps even of never using them."

In the present depressed state of business, the temptation to make more favorable offers is so strong, that some manufacturers may be willing to overstep the bounds of prudence, under a hope to work off

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[1] *Annales des Mines*, vol. x, pt. 4.

the temporary surplus of iron stock at some favorable future opportunity. If the hope is not realized, there is reason to fear that excuses will be found for filling remote orders with a metal of inferior quality. C.

Relation between Meteorologic and Magnetic Disturbances.—In a communication to the Belgian Academy, Van der Mensbrugghe remarked: "If the least quantity of vapor which arises from a liquid, produces a diminution of temperature and electric disturbance, what powerful thermal and electric effects may we not expect from the immense variations of free surface in the waters which cover the earth, and in the vapors which rise into the air?" Secchi has stated the following principles: "1. Every rupture of meteorologic equilibrium which produces condensation in rarefaction of vapor, produces a rupture of electric equilibrium. 2. The equilibrium can only be restored by means of a current which is discharged from place to place on the earth's surface. 3. This current cannot fail to act on magnetometers, and to be shown by them." In a recent letter to the Belgian observer, Secchi writes: "I have wished to discuss the observations of recent years, which show a marked diminution of auroras, sun-spots and magnetic variations, and I have always found a decided correspondence, especially in the movements of the bifilar and the vertical. Only, as I should have expected, the excursions were smaller, and we have not had, of late years, those gigantic fluctuations which gave me so much trouble at the time when the observatory was founded. But the variations of the means are so well defined that one can judge the state of the sky by the march of the magnetic instruments. Even when the barometer does not show a great variation, there is always some other element which manifests a distant atmospheric disturbance (change of wind, storm, etc.), especially in summer."—*Ex.* C.

Heat-Conductivity of Metals and Paper.—M. Aymonnet finds: (1) that metals and paper are not, as is generally thought, athermanous; (2) that they are more diathermanous for the obscure radiations from metallic bodies below the temperature of boiling water than for luminous calorific rays; (3) that their absorptive powers are more feeble than those of water; (4) that there is a mathematical relation between the absorbing power of a body and its coefficient of conductibility.—*Les Mondes*, Feb. 22, 1877. C.

India Ink, of a deep black, which gives neutral tints for half-shades, is very rare. It may be made as follows: Rub thoroughly together 8 parts lampblack, 64 parts water, and 4 parts of finely pulverized indigo. Boil until most of the water is evaporated, then add 5 parts gum arabic, 2 parts glue, and 1 part extract of chicory. Boil the mass again till it is thickened to a paste, then shape it in wooden moulds which are rubbed with olive or almond oil.—*Papier-Zeitung*, Feb. 15, 1877. C.

Relation between Viscosity and Temperature.—Silas W. Holman has published an abstract[i] of a paper read before the Amer. Academy of Arts and Sciences, June 14th, 1876. From the results of a number of careful experiments he concludes that the "viscosity of air increases proportionately to the 0·77 power nearly, of the absolute temperature, between 0° and 100° *C*." The extreme range of his results is from ·738 to ·799. E. Warburg, under date of 9th July, 1876, publishes the results of similar experiments,[ii] both with hydrogen and with air, deducing the exponents between 20° and 100°, ·76 for air (the extremes being ·74 and ·76), and "about $\frac{2}{3}$" for hydrogen (the extremes being ·57 and ·65). The closeness, the narrow range, and the mutual confirmation of these results, obtained nearly simultaneously by two independent investigators, are very interesting. The atmospheric exponents seem to indicate a new analogy between molar and molecular forces. For the viscous particles, so far as they are affected by the same movements, may be compared to the rotating particles of a solid nucleus; the thermal undulations, in a supposed ethereal medium, present a like analogy to the motions of an elastic atmosphere. In a contracting or expanding nebula, the limiting radius between constrained rotation and free revolution varies as the $\frac{2}{3}$ power of the time; the nucleal radius, on account of the law of equal areas, varies as the $\frac{1}{2}$ power of the time. Therefore the nucleal radius varies as the $\frac{3}{4}$ power of the atmospheric radius.[iii] The well-known anomalies, in the elasticity of hydrogen, are in accordance with its low viscosity. Warburg's extremes (hydrogen ·57, air ·76) seem to point towards secondary nucleal and atmospheric relations between air and hydrogen.

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[i] *Lon., Ed. and Dub. Phil. Mag.*, Feb., 1877, p. 81.

[ii] *Pogg. Ann.*, clix, 415.

[iii] *Proc. Am. Phil. Soc.*, xvi, 305 *et al.*

THE METALLURGY AND ASSAYING OF THE PRECIOUS METALS USED IN COINAGE.

[Abstract of the Second Lecture delivered before the Members of the Franklin Institute.]

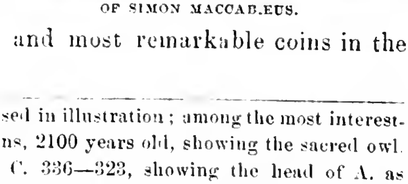
By Alexander E. Outerbridge, Jr., Assay Department, U. S. Mint, Philadelphia.

ON SILVER.

In my last lecture I traced the history of gold from its earliest mention in the Bible, in the marvelous accounts of the early classic authors, and of the alchemical writers of the middle ages, down to the production of the present day.

Silver was likewise known from the most ancient historic period, and even antedates gold as a medium of exchange. Its frequent mention in Scripture proves its familiar employment among the Jews. The shekel was a silver coin, and as it is very interesting, not only historically, but as revealing the state of coinage in the time of Simon Maccabæus, whose reign began 143 B. C., we will project its image upon the screen by means of the megascope.

SHEKEL



OF SIMON MACCABÆUS.

On the reverse side you see the budding rod of Aaron, with the legend *Jerushalaim ha-kedoshah* in the Samaritan character, which is, translated, Jerusalem the holy. On the obverse is the pot of manna, with the words *Shekel of Israel*. This is one of the rarest and most remarkable coins in the mint cabinet.[1]

[1] Several curious old silver coins were used in illustration; among the most interesting were the stater, or 4 drachms of Athens, 2100 years old, showing the sacred owl. The stater of Alexander the Great, B. C. 336—323, showing the head of A. as Hercules with the lion's skin. A silver coin of Sapor, one of the Magian or fire worshiping kings of Persia, preceding the rise of Mohammed, A. D. 300. Denarius of Tiberius, A. D. 14–37, this was the *penny* of the New Testament. A silver coin struck in the time of the Roman Emperor Vespasian, A. D. 69–79, to commemorate the destruction of Jerusalem, with a figure of a weeping woman. And, finally, proof coins of our own mint, for 1877. The slow growth of art and gradual development of mechanical improvements in coinage, were very rapidly demonstrated in this manner.

PHYSICAL AND CHEMICAL PROPERTIES.

We are at once impressed with the brilliant lustre and pure white color of the virgin metal. This property is beautifully shown by the little *granule* of chemically-pure silver reflected on the screen, and magnified to the size of half a ton.

In its malleability and ductility, silver ranks second only to gold. Here is a book of silver leaves. They are so light that they float about on the surface of water, and if I hold some of them over the ascending current of warm air from the register on the floor, they are wafted through the room like thistles in the breeze.

Silver dissolves readily in nitric and in concentrated boiling sulphuric acids. Both of these solvents are used in the mints for the refining of the metal. A great number of re-agents precipitate silver from its solution. We will merely consider a few of the most characteristic and important. This tall jar contains salt water, and here is a silver quarter dissolved in acid; they both form clear solutions. By pouring the silver into the salt we obtain a white, flocculent cloud, falling like a miniature snow shower. The fickle chlorine gas, which was before united with the sodium, forming common salt, has changed partners with the nitric acid, and we have as a result, chloride of silver precipitated and nitrate of soda in solution. This test is of great value in the analysis of silver, and is an exceedingly delicate one, as I shall now endeavor to show you. I am holding in the forceps a tiny particle of silver which weighs just one-hundredth part of a single grain. I put it into a test tube containing a few drops of nitric acid, and it is immediately dissolved. The little glass tank in the lantern, reflected on the screen, contains a common sea-water bath, sufficiently enlarged to make a pretty formidable wave. I now add our drop of nitrate of silver, and I think you can all notice a cloud, the size of a man's hand, forming upon the screen.

Silver melts and volatilizes at a much lower temperature than gold; I place a particle of it on the lower carbon electrode, and you all see the superb emerald-green flame it produces, which is even more beautiful and brilliant than was the vapor of gold.

SOURCES IN NATURE.

Silver is found in the metallic state nearly pure, sometimes in enormous masses, weighing several hundredweight; but it is more frequently combined with other elements, such as sulphur, antimony,

lead, arsenic, etc. The process of extraction from the ore is, therefore, much more complicated than is the case with gold. It is also found over a wider range of geological periods. It occurs in true veins in the older crystalline and metamorphic rocks, in calcareous rocks, and even in the carboniferous period. The large colored geological chart of the world, together with the paintings, will serve to give you a pictorial impression of the natural distribution of the precious metals, and the means adopted for their separation.

My friend, Mr. J. A. Clay, whose valuable cabinet of minerals some of you may have seen, has kindly placed at my disposal his gold and silver specimens; many of these are quite rare, and the megascope will enable you all to appreciate their beauty. Perhaps one of the most remarkable of these is the ruby silver, enclosed in a transparent crystal of quartz.

The most famous mines of the old world are to be found at Kongsberg, in Norway, and at Sala, in Sweden. The silver mines of Spain have been worked from the most remote period by the Phœnicians, Romans and Moors in turn. In fact nearly all the countries of Europe have added their quota to swell the general stock in existence, both of silver and gold.

Mexico formerly produced two-thirds of the product of the whole world. You all remember the famous cake of silver that attracted so much attention in the Mexican Court at the Centennial Exhibition. This cake was afterwards cut up by steam shears, and brought to the mint. It weighed about 4000 pounds, contained $\frac{960}{1000}$ of pure silver, and was worth $68,149.

The famous mines of Potosi, in Bolivia, were discovered in 1545, and were estimated by Humboldt to have produced $1,150,000,000 worth of silver.

Coming now to the United States we find here the greatest mines of the world. Nevada and Colorado are treasure houses of apparently inexhaustible wealth. The presence of veins of silver throughout the territory of Nevada was comparatively unknown until 1859, when the Comstock vein was discovered. "The region was then regarded as an irredeemable wilderness, a land of deserts and death, over which the early pioneers had passed as rapidly as possible in the tide of emigration to the gold regions of California. The scene has changed, Nevada from a comparatively unknown portion of Utah became first a territory and then a state in the Union. The valleys and deserts resound with the shrill whistle of engines and falling of

stamps. The little valleys are brought into cultivation; graded roads are made over apparently impassable mountains; mails arrive and depart daily, and the telegraph connects the business centres with those on the Pacific and Atlantic coasts. All this has resulted chiefly from the discovery of the celebrated Comstock lode, which has already added nearly $80,000,000 in value to the bullion of the world." [1]

In 1876, the Consolidated Virginia mine alone is reported to have yielded 145,666 tons of ore, the value of which was $16,661,940. Colorado yields at the present time a daily average of $15,000 in silver, and $10,000 in gold. The mines of Utah yield a daily average of $12,000 in silver.

REDUCTION OF ORES.

The ancient method of extracting silver from its ores was exceedingly crude, requiring a period of several months in the operation. In the old Mexican process, the ore was ground to a fine powder in circular paved pits or mills called *arrastras*, by means of large stones attached to a shaft drawn round by mules (resembling the manner in which clay is still mixed in some of our brick yards); water was added and the argentiferous mud was piled into heaps and left exposed for a considerable time to the action of the atmosphere. It was then mixed with common salt and copper pyrites called *magistral* by driving mules backward and forward over the mass. Mercury was added which combined with the silver to form amalgam and the dross washed away.

The excess of mercury was removed by squeezing the amalgam in canvas or chamois skin bags. This method is said to have been

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[1] "From the Comstock the explorations extended in all directions, and resulted in the discovery of gold and silver bearing veins in most of the principal mountain ranges that traverse the great basin in a general north and south direction. First the metal was traced southward to Esmeralda, Mono, Coso, Walker's River, Owen's River, and the slate range near the southern end of the Sierra Nevada. Eastward the Humboldt mines, Reese River, Goose Creek, Egan Cañon, and Utah Mines, were reached in succession, and the discoveries have been extended eastward to the ranges of the Rocky Mountains, where the prospectors met those of Colorado. Northward in connection with the gold prospectors of Oregon, the precious metals were traced into Idaho, Montana, and British Columbia, and southward, veins have been discovered along the ranges reaching into Arizona, extending the silver region to Sonora, thus connecting the whole with the great metalliferous belt of the Mexican plateau; and with the discoveries of the extreme north, proving a continuous zone of mineral wealth through North America, from Panama to the Arctic Sea."—*Prof. Blake's Report upon the Precious Metals.*

invented in the year 1557 by a miner named Bartholomew de Medina. Nearly all the modern improvements, are merely mechanical modifications of detail, but the advantages of machinery are so great that as much can now be accomplished in a few hours as formerly required several months.

The usual method at present adopted is to roast the silver ores containing sulphur with from six to twelve per cent. of common salt. About 1000 lbs. of ore constitute a charge. The heat volatilizes the sulphur and the chlorine unites with the silver. After the ore has swelled into a spongy condition it is thoroughly sifted and placed in barrels holding 1000 lbs. each, mercury is added and the barrels are revolved for about 20 hours. Modifications of this process are adopted in some cases, to shorten the time; the mercury is sometimes delivered in a fine spray while the ore is kept hot. In order to separate the mercury the amalgam is dried, rolled into balls, and placed in hermetically-sealed retorts. The mercury is driven over and condensed, and the silver is cast into bars (called *pigs*) for shipment. Efforts have been made to effect the removal of the silver without the aid of mercury, and several methods of solution and precipitation have been devised. Ziervogel's process is exceedingly ingenious. The *matt*, consisting of sulphurets of silver, copper and iron, is roasted. The copper and iron first change to sulphates and then to oxyds. The sulphuret of silver also subsequently becomes sulphate, and if the heat were continued would be reduced to the metallic state; as this is not desired, the roasting is discontinued, and the silver is found as a *soluble sulphate*, which is then dissolved in hot water. The silver is precipitated by means of copper plates. The principal objection to this method of reduction is that the presence of certain impurities, such as antimony or arsenic, cause the formation of insoluble salts, which retain a portion of the silver.

Von Patera's process consists in converting the silver into a chloride by roasting with salt. It is then dissolved in a cold dilute solution of hyposulphite of soda. It is next precipitated in the form of sulphide by the addition of polysulphide of sodium, and finally reduced to the metallic state by melting in a furnace while exposed to the atmosphere.

All the processes of solution are comparatively modern, and possess advantages in several ways over the old amalgamation methods.

MINTING.

Silver bullion is received at the mint in the form of bars, pigs, doré silver, old plate and coin. We have even received, in former days, whole altars of silver from Mexico, and Saints innumerable, which were ruthlessly cast into the fiery furnace.

The bullion is frequently rendered exceedingly "short" or brittle by the admixture of base metals. These, of course, require to be eliminated in order to render the metal fit for coinage, and the process is technically called "toughening." The metal is melted in a sand pot with an oxidizing agent, such as nitre, together with a protective covering of borax. The oxygen of the nitrate of potash combines with the base metals, forming volatile oxides; these are partially dissipated and partially dissolved in the borax. The precious metal is then cast into bars, and still another process, known as "parting," is required to separate the silver from the gold. For this purpose the silver deposits containing gold, and the gold deposits containing silver, are melted together so as to make the relative proportions about two pounds of silver to one of gold; formerly three parts of silver were considered necessary; hence the old name, "inquartation." The metal is broken up into *granulations* by pouring it from the melting pot into ice-water; these are placed in large porcelain jars having a capacity of 50 gallons each. Nitric acid is added and steam heat applied for several hours. The silver is converted into a soluble nitrate, and the gold settles to the bottom in the form of brown powder.

By means of a large gold siphon the solution of silver is transferred to a wooden vat containing salt water, having a capacity of 1200 gallons. The precipitated chloride of silver is collected on filters, washed, and reduced to the metallic state by means of granulated zinc and dilute sulphuric acid. Here is another instance of the base inconstancy of the pungent chlorine; having first deserted the sodium for the silver, it already sighs for new elements to conquer, and takes to itself the metal zinc, leaving the silver without a partner. The silver does not now present the beautiful appearance of the virgin metal, but requires purification by the "tryall by fire." It is accordingly pressed into large cakes, dried in an oven at a moderate heat, and melted in large crucibles. It is then cast into fine bars for stamping, or the requisite proportion of $\frac{1}{10}$ of copper is added for coin ingots.

In most of the foreign mints, as well as at the assay office in New York, the parting is effected by means of concentrated boiling sulphuric acid in cast iron kettles. The silver and copper are converted into soluble sulphates, while the gold remains untouched. Sulphurous acid gas is largely developed; this is sometimes conducted into leaden chambers and condensed into sulphuric acid. The silver is then reduced to the metallic state by means of copper plates. The sulphate of copper formed is crystallized in flat pans or vats, and becomes a valuable product. The advantages of this method are in the cheapness of sulphuric acid as compared with nitric, and in the fact that all the copper originally in the alloy is recovered in the form of blue stone, while in the nitric acid process it is lost in the solution of nitrate of soda.

The most recent improvement in refining which seems to combine the three valuable concomitants, of cheapness, simplicity and dispatch, is the *chlorine process* devised by Professor F. Bowyer Miller, of the Sydney Mint, Australia. A current of chlorine gas is passed through the metal while in a molten state; the gas combines with avidity with all the metals except gold, converting the base metals—such as lead, zinc, tin, antimony, etc.—into volatile chlorides, which escape up the chimney. The chlorides of silver and copper being comparatively non-volatile, are retained by a protective covering of melted borax, and, being lighter than the molten gold, they float upon its surface. The pot is then removed from the fire, the gold quickly "sets," and the combined chloride of silver and copper is poured into moulds.

Extended tests of his process were made by Professor Miller at our mint, a few years since, which proved entirely successful. The gold was found to be as nearly pure as by the other methods in use, and the chloride of silver may be reduced in the ordinary way. This ingenious method was devised for the especial purpose of recovering the silver in the native gold of Australia, which often amounts to as much as 14 per cent., but which was formerly lost to the colony, owing to the too great expense of acids in that country.

ASSAYING.

In my first lecture I gave you a brief outline of the method of assaying gold by cupellation. Silver was also formerly assayed in the same way, but it was long known that the result was not quite

accurate, owing to the partial volatility of the metal. Experiments were instituted by the French government, which resulted in the beautiful "volumetric process" devised by Gay Lussac. This is one of the most accurate methods known to chemical science, and so complete was Gay Lussac's original description, that but little room has been left for any improvements, and many thousands of dollars' worth of silver are rapidly and accurately assayed every day in the mint in this way. The rationale of Gay Lussac's method is quite easy to understand, viz., *a given proportion of chlorine will precipitate a definite amount of pure silver.*

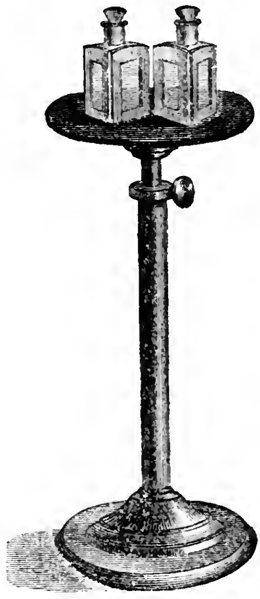
We prepare two solutions of common salt water (chloride of sodium), one is known as the "normal solution," the other as the "decimal solution," one begins and the other finishes the assay. Here is a pipette holding just one hundred grammes of the normal solution, which is made of such a strength that it will precipitate exactly one gramme of pure silver. In this bottle, I have a piece of a silver coin of a definite weight, dissolved in nitric acid, and when the pipette charge of normal salt water is added to it, you see the dense white precipitate which permeates the whole liquid. I now agitate the bottle rapidly for a few moments and the precipitate falls to the bottom, leaving a clear solution above. Is any silver still unprecipitated? Let us see. Here is a glass tube with graduated divisions, each division marks one-hundredth the capacity of the large pipette, and here is a solution of salt just one-tenth the strength of the other. I allow the charge of decimal salt water contained in one division of the glass tube to flow over the surface of the silver solution in the bottle, and a cloud is forming on the top. Now, as this charge of salt is $\frac{1}{10}$ *the strength and* $\frac{1}{100}$ *the volume* of the normal solution before added, I know that I have precipitated just $\frac{1}{1000}$ *as much silver*, or one milligramme. The bottle is again agitated until, after four decimal charges have been added, only a very faint *shadow of a cloud* appears, and I am now sure that all the silver is precipitated. A simple rule-of-three sum, gives us the proportion of fine silver in the original weight of alloy.[1] It is not necessary to weigh the precipitate, and even the

[1] The gramme with its decimals is universally adopted by assayers for accurate scientific work, the jewelers' "carat" having been entirely discarded within the last half century. Twenty-four carats represent purity, or 1000 fine. 18 carats mean two-thirds fine or 750-thousandths. Our "standard" for both gold and silver coin is 900 parts of precious metal, and 100 parts of copper; in other words it is nine-tenths fine.

calculation is saved by using Gay Lussac's tables. But perhaps you may think that the strength of the salt solution must vary with changes in the temperature; so it does, but this and other minor sources of error are corrected by testing the strength of the solution every day by means of a "proof assay," made of chemically-pure silver.[1]

SPECTRUM ANALYSIS.

Most of you are, no doubt, familiar with the principles of the captivating study of spectrum analysis. You know that a beam of white light from the sun, or from this powerful electric lamp, is a very complex thing indeed. It is composed of a number of different and distinct rates of vibration of the luminiferous ether, which may reveal themselves to our physical sense of sight as a band of beautiful colors (as in the rainbow), but which are ordinarily so blended together upon the retina that we fail to distinguish the component elements; just as when we listen to a symphony played by a fine orchestra, we appreciate the combined harmonies while we lose the sound of the individual instruments. By inserting this prism in the path of the beam of white light coming from the electric lamp, we can sift out the primary rays, and now we have upon the screen a palette of the purest rainbow colors, spread by nature's own artistic hand, and shading into each other with an exquisite blending far surpassing the fondest dreams of a Titian or a Turner.



STAND, WITH TWO PRISMS.

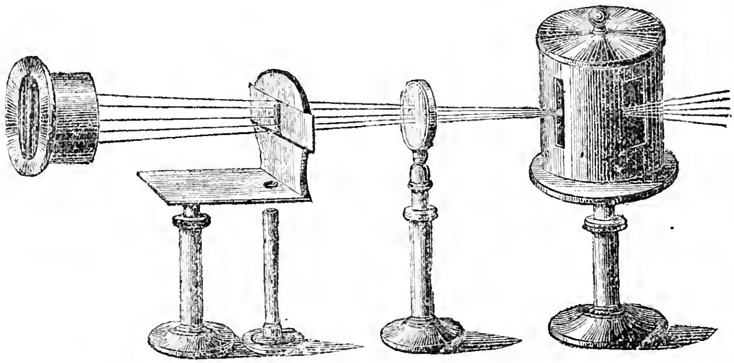
What would be the effect if, in place of this brilliant *chromatic symphony*, we could produce a *luminous solo* by means of a light of a single color?

There is a fundamental mono-chromatic note in the spectrum, which I wish to have as familiar, to your eye, as our national tune is to

[1] Mercury is the only foreign element liable to cause an error in the humid assay. Its presence, even in minute quantity, may be detected by a peculiar haziness in the liquid. A mere trace will prevent the blackening of the chloride of silver in strong sunlight. I believe that this is a fact not generally known.

your ear, for it is the key-note to the whole study of spectroscopic analysis. I therefore place in the electric arc a particle of sodium; this metal is capable of vibrating, when vaporized, at only *one note of color*, and hence you now see upon the screen a single band of intensely yellow light. Please to fix the position of this yellow line in your memory. It is called the "D" line, and is regarded by spectroscopists as a sort of *tuning fork* by which the positions of all the other notes in the chromatic scale are compared. I shall now vaporize a particle of pure gold and pass its light through the prism, ah! there it has *written its signature* upon the screen, in lines of brilliantly colored light, which nature never counterfeits.

Next we will call for the autograph of silver, and you see the beautiful green lines so characteristic of this metal. Then comes



APPARATUS FOR PROJECTION OF SPECTRA.

copper, determined to outshine the others in its bold chirography; and, finally, when we vaporize an alloy of all three metals, we have the signatures of each written without confusion, and endorsed by the infallible authority of nature herself.[1]

We have thus seen that the terrestrial elements (even when alloyed together), in the state of incandescent vapor, write their own distinctive autographs in the spectroscope, whereby each one may be easily recognized. But, you may ask, can these signatures also tell us the relative proportions in which the metals are combined? "Ay, there's the rub." This is the great problem that scientists are trying to solve to-day, and which I hope, and almost believe, we will

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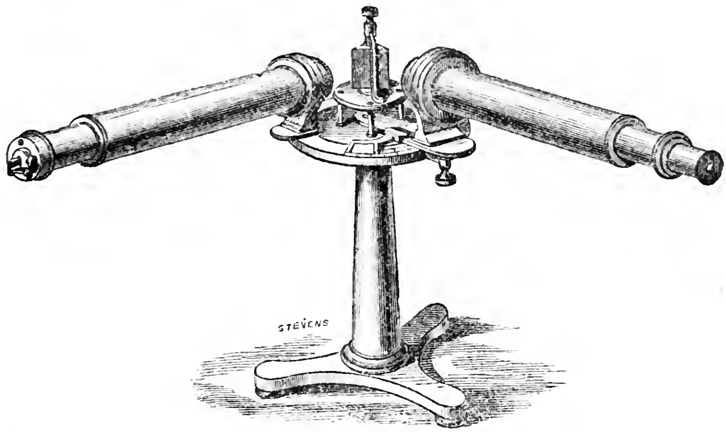
[1] By plugging the metal firmly into the cavity in the lower carbon, and filing it down to a cone, thus forcing the current to pass constantly from the molten globule, an uninterrupted spectrum was obtained in each experiment.

yet see accomplished. A step in this direction, which seemed to promise hope of success, was made some time ago by Mr. J. Norman Lockyer, the English astronomer. You know that when powerful electric sparks (from an induction coil) are passed between two terminal points of metal to be examined, a small portion of the metal is vaporized; its spectrum is then examined through an instrument of this kind.



SPECTROSCOPE.

Mr. Lockyer noticed while studying these luminous autographs, that when he separated the metallic electrodes, causing the spark to leap a greater distance through the air, the spectral lines no longer continued to cross the entire field of vision, but certain of them broke in the middle; and upon further increasing the distance between the electrodes, the hiatuses in the spectral lines increased proportionately, but unequally with different alloys. Upon this discovery Mr. Lockyer based the theory of a possible quantitative analysis.

The spectroscope was known to be marvelously sensitive to the impression of these autographs, and it therefore appeared plain that could such a method of analysis be reduced to a practical basis, its value would be immense in assaying metals used in coinage. For although the present modes of assaying precious metals have been brought to great perfection, yet the process is slow and tedious, requiring many chemical operations and great delicacy of manipulation; and "there is something captivating in the idea of a determination, as it were, by a flash of lightning, or in the twinkling of an eye, what proportion of gold or silver is present in any bar or coin."

It was with the hope of reducing this beautiful theory to practice that I undertook, with the approbation of the chief assayer of the mint, an extended investigation in the assay laboratory, a portion of the work being performed at the University of Pennsylvania with the excellent apparatus and appliances afforded in the new college building. As the result of this investigation was published in the form of a report to the assayer, in the *Proceedings of the American Philosophical Society*, and afterwards as an article for the JOURNAL OF THE FRANKLIN INSTITUTE, it is unnecessary to do more than allude to a few of the experiments.

Various grades of alloys of gold, silver, and copper, were prepared, and their exact composition determined by careful assays. A special apparatus which you see upon the table, was constructed to hold the metal slips when under examination. Its peculiarity consisted in an automatic combination of accurately proportioned screws acting in opposite directions, by means of which a single motion of the hand sufficed to cause the upper and lower electrodes to approach or recede from the central line of contact in *an equal degree.* Its object was to admit of the electrodes being separated to any desired extent, while preserving the line of vision through the spectroscope directed to the centre of the spark. I found that while a decided difference in the spectral lines could be observed between alloys of comparatively wide variation, I was unable to detect any appreciable distinction between those varying but slightly in their composition. Several curious and unexpected anomalies were noticed in the course of this investigation, but the principal source of difficulty appeared to be owing to the infinitesimal amount of metal vaporized by the spark. I found, for instance, that when small electrodes were accurately weighed upon the delicate assay balance a thousand sparks might be passed between these points, each spark producing a brilliant spectrum of the metal, and yet the total loss in weight was only one-thousandth part of a grain; that is to say, each spark vaporized one-millionth part of a grain! Now, as I have already shown you, it is necessary to determine assays of the precious metals to the one-ten thousandth part of the normal assay weight, and it is hardly conceivable that a discrimination to the one-ten thousandth part of the *spark* assay weight or the *one-ten billionth* of a grain is practically possible. Even if it were so, the present state of metallurgy is not sufficiently perfected to enable us to mix the alloy so homogeneously

that we could safely assume that a test on such an atomic scale would correctly represent the value of a large deposit.

While there are several apparent paradoxes which have not as yet been explained, judging by former experiences in which even more mysterious problems have been resolved by study, we are surely warranted in anticipating, that when a larger number of observations, to be made, perhaps, by many experimenters, shall have been collated, the true scent may suddenly be struck, which shall discover the desideratum of quantitative spectroscopic analysis of metallic alloys.

CALORIFIC INTENSITY OF SOLAR RAYS.

NOTE OF M. A. CROVA.

"In previous communications,[i] I have indicated the methods of observation and of calculation, which I have adopted in my researches. It was interesting to inquire what are, at different epochs of the year, the quantities of heat received during a day by the horizontal surface of the soil; these determinations may excite an interest in the study of the phenomena of vegetation, and furnish facts for the study of the propagation of solar heat in the earth. With this aim, I have calculated the observations made during two normal days, during which the sun shone without interruption, days remarkable for the continuity of the atmospheric diathermaneity, and chosen as near as possible, the one to the winter solstice, the other to the summer solstice.

"I have already given[ii] the measurements of calorific intensity in the solar rays, made at Montpellier during the 4th of January, 1876. This series was remarkable for the clearness of the sky and the general symmetry of the hourly curve of calorific intensities. The total quantity of heat received during the whole day, normally to the direction of the solar rays, upon a surface of 1 sq. centimetre, could be obtained by integrating the hourly curve, but it is more simple and equally precise to trace the hourly curve of the calories from sunrise till sunset, and to *weigh* the area of the curve thus obtained. If the paper is of uniform thickness, the weight of this area, compared with the weight of the rectangle in which it is inscribed, will give the

[i] *Comptes Rendus*, lxxxi, p. 1205, and lxxxii, pp. 81 and 375.

[ii] *Memoires de l'Acad. des Sciences et Lettres de Montpellier*, 1876, p. 61.

total value of the calories received in this interval, normally to the sun's rays; by previously weighing rectangles of different surfaces, from the paper which I used, I assured myself of the proportionality of their surfaces to their weights.

"On the other hand, I traced upon the same paper the curve which gives, for each observation, the product of the calorific intensity of solar radiation by the cosine of the sun's zenith distance at the middle of the observation; the weight of this curve measures the total heat received by 1 sq. centimetre of the horizontal surface of the soil, from the moment of sunrise till that of sunset.

"I made a complete series of observations on the 11th of July, 1876, near the shore of Palavas, 12 kilometres from Montpellier; this day was remarkable for the clearness of the sky, and the steadiness of a light northwest wind that weakened the disturbing influence of the sea breeze, which was not perceptible at the surface of the ground. The horizon being free in all directions, I was able to measure, without interruption, from sunrise to sunset, by means of two actinometers carefully compared and simultaneously observed, the calorific intensity of the direct radiation, and that of the part which was transmitted through a layer of water 1 centimetre thick.

"The observations of July 11th show the want of symmetry peculiar to summer days; after weighing the hourly curves of the morning and evening calories, and doing the same for the curves of the products of calorific intensities by the cosine of sun's zenith distance, I calculated the total value of the quantities of heat received during this day, normally to the solar rays and by the horizontal surface of the soil, upon an area of 1 sq. centimetre. The results of these measurements for the two days are as follows:

"JANUARY 4TH, 1876.

	Heat received on 1 sq. centimetre.	
	Normally.	On the surface of the soil.
1. From sunrise till noon,	264·4	78·9
2. From noon till sunset,	270·6	82·3
3. From sunrise till sunset,	535·0	161·2

"The calories received normally varied between 0 and 1·29, in 9 hours of exposure.

"The calories received on the earth's surface varied between 0 and 0·53, in 9 hours of exposure.

"The heat received on the earth's surface, is ·301 of the normal heat.

"July 11th, 1876.

	Heat received on 1 sq. centimetre.	
	Normally.	On the surface of the soil.
1. From sunrise till noon, .	451·5	293·5
2. From noon till sunset,	424·9	280·6
3. From sunrise till sunset,	876·4	574·1

"The calories received normally varied between 0 and 1·21, in 15 hours of exposure.

"The calories received on the earth's surface varied between 0 and 1·10, in 15 hours of exposure.

"The heat received on the earth's surface, is ·655 of the normal heat.

"The heat received normally on Jan. 4th, is ·610 of that received on July 11th.

"The heat received on the earth's surface on Jan. 4th, is ·281 of that received on July 11th.

"These results give a precise measure of the irregularities produced, in summer and in winter, by the obliquity of the solar rays, and by the duration of the sun's appearance above the horizon, between the absolute values of the intensity of solar radiation, and between the ratios of the quantity of heat sent directly, to that which is received upon the horizontal surface of the soil."—*Comptes Rendus*, March 12th, 1877. C.

Academy of Natural Sciences.—Part III of the Proceedings, for 1876, contains: Self-fertilization in Mentzelia ornata, *Meehan;* Direct Growth Force in Roots, *Id.;* Interpretation of varying forms, *Id.;* On the Marine Faunal Regions of the North Pacific; An Introductory Note to the Report on Alaskan Hydroids, by Mr. Clark, *Dall;* Report on the Hydroids collected on the coast of Alaska and the Aleutian Islands, by W. H. Dall, U. S. Coast Survey, and party, from 1871 to 1874, inclusive, *Clark;* On the Extension of the Seminal Products in Limpets, with some remarks on the Phyllogeny of the Docoglossa, *Dall;* Descriptions of some vertebrate remains from the Fort Union Beds of Montana, *Cope;* On Conglomerate No. XII, *Young;* The Australians, *Pickering;* On Sonomaite, *Goldsmith;* Explorations in S. America, *Cope;* On Boussingaultite and other minerals from Sonoma County, *Goldsmith;* Report on Insects introduced

by means of the International Exhibition, announcing "with moderate certainty, that no evil results will occur to our agricultural interests, from any introduction of foreign insects, by means of the Centennial Exhibits," *Le Conte*, chairman; Notes on a Cirripede of the California Miocene, with remarks on Fossil Shells, *Conrad;* Notes on American Cretaceous Fossils, with descriptions of some new species, *Gabb;* On Ozocerite, *Leidy;* On Hyraceum, *Id.;* On Itacolumite, describing specimens "reported to be from Mariposa Co., Cal., which are interesting and worthy of note by reason of the new locality, and as showing the peculiarities of this kind of sandstone in a marked degree," *Blake;* Mineralogical Notes, *Willcox;* Impurities in Drinking Water, stating that "during the last eight years, whenever the Schuylkill has been covered with ice, he observed that the water supplied by the city possessed a disagreeable odor and taste like chlorine," *Id.;* On Excrescences and Eccentric Wood Growths in the Trunks of Trees, showing that "there was no reason why cells, predestined, under ordinary circumstances, to be merely bark cells, in their change from wood cells should not occasionally retain enough of growth force to carry on a feeble wood constructing system of their own," *Meehan;* Pickeringite from Colorado, *Goldsmith;* Epsomite on Brick Walls, accounting for the whitish incrustation at the beginning of winter, *Id.;* Notes on Fishes from the Isthmus of Panama, *Gill;* On some Extinct Reptiles and Batrachia from the Judith River and Fox Hills Beds of Montana, *Cope;* Our Sidereal System, and the Direction and Distance to its centre, *Ennis.* C.

Prize for a method of Detecting Adulterations of Butter.— The bureau of the LeipzigPharmaceutical Union, offers a prize of 300 marks for the discovery of a sure and practical method for the detection of adulteration of butter by other fatty substances. Professors Dr. Heintz, in Halle, and Dr. Knop, in Leipzig, have consented to act with Herr Kohlmann as judges in awarding the prize. Each competing essay is to be provided with a motto and accompanied by a sealed note, containing the motto on the outside and the author's name on the inside, and both are to be forwarded to Herr Kohlmann, Apothecary, in Leipzig-Reudnitz, before September 30th, 1877.—*Dingler's Polyt. Jour.*, 223, 2, Jan., 1877. C.

ORNAMENTAL IRON WORK.

[Abstract of the second lecture in Prof. Pliny E. Chase's course, on "Lessons of the Centennial," delivered before the Franklin Institute, March 13th, 1877.]

The earliest historical reference to iron is found in Genesis, iv, 22. "Tubal Cain, an instructor of every artificer in brass and iron," lived, according to Biblical chronology, about 3700 B.C. He is supposed by many, and with good reason, to have been the same as Vulcan. He was not merely a smith, but he was an ornamental iron worker, "an instructor of every artificer." The Hebrew word *khoresh*, "artificer; cutting instrument," is akin to *kheresh*, "cunning worker;" both being derived from *kharash*, "to cut, carve, engrave, sculpture." Among other Biblical allusions we may note "an instrument of iron," Num., xxxv, 16; the giant Og's "bedstead of iron," Deut., iii, 11; "chariots of iron," Josh., xvii, 16; "saws, harrows of iron and axes of iron," 2 Sam., xii, 31; "chains and fetters of iron," Ps., cxlix, 8; "an iron pillar," Jer., i, 18.

Some doubts have been expressed whether Homer knew anything of iron, but Hesiod, who, according to Herodotus, was a contemporary of Homer, speaks of the "iron age," and the iron money of Lycurgus was in circulation about 850 B. C. Notwithstanding the interference of rust with the preservation of iron work, iron hatchets have been found in the Etruscan tombs; an iron forge, tools and nails among the lake dwellings of Switzerland; and iron pillars are still standing in India, which are supposed to be more than 1500 years old. Rings, both of gold and of iron, circulated as money in Britain, at the time of the Roman conquest, but they were probably imported. Iron works were in active operation upon the island, A. D. 120.

The peculiar combination of carbon with iron, which we call steel, and the art of tempering, seem to have been known in prehistoric times. At the beginning of the Christian era the best steel was imported into Rome from China, that of Parthia being of inferior quality. Steel armor was in common use among the soldiers of William the Conqueror. Steel was manufactured in Sweden as early as A. D. 1340, but the art of fusing steel in a crucible, and then casting it into bars so as to form a homogeneous "cast steel," was invented at Sheffield in 1750, and was long kept secret. Bessemer steel is pre-

pared by forcing a powerful current of air through a quantity of melted iron. The oxygen of the air, uniting with the carbon and silicon and other impurities of the iron, produces a rapid combustion and intense heat. The blast is continued until the carbon is nearly all consumed, when an alloy called "ferro-manganese" is added, in such proportions as are needed to re-carbonize the metal and produce such "low" or "high" grade of steel as may be required. The largest present use of Bessemer metal is in the manufacture of steel rails of a "low" grade, combining great tenacity and durability, with slight brittleness and feeble tempering properties. The bends and twists and cuts and tensile tests, of the specimens on the table, show how admirably this material is fitted for artistic ornamental treatment.

The art of casting iron seems to be quite a modern one, but the date of its invention is uncertain. There is a cast iron grave-slab in Sussex, Eng., made about A. D. 1350. A minute proportion of phosphorus, which renders iron wholly unfit for the Bessemer process, adds greatly to its fluidity, as is shown by the remarkably sharp and beautiful ornamental castings in Berlin iron. The Centennial display, by American iron founders, of cast statuary, vases, railings, bronzed and enameled work, stoves, grates, etc., showed a taste of design and care of execution worthy of almost unqualified praise. The architectural combination of cast and wrought iron, in the structure of the main building, also produced many pleasing and commendable effects. But there seems to have been little thought of the admirable results which might be reached, by a treatment similar to that of the best Japanese bronzes; the casting being regarded merely as a convenient way of forming a mass which can be more readily cut into shape than a larger piece of metal.

Both cast and wrought iron admirably illustrate the importance of the great natural principle of oscillation or vibration. It is now commonly believed that no two material particles are in absolute contact, but that, even in the most solid substances, there are continual internal tremors and orbital motions, much more complicated than those which keep the planets and "stars in their courses," and yet governed by similar laws. In consequence of such internal motions, glaciers and rocks and metals can be made to "flow," not only through the intervention of the fiery fingers of heat and flame, but also by simple continuous pressure. M. Tresca, who has studied the subject very carefully, is unable to find any limit between the fluid

and the solid conditions of matter. There are merely differences of viscosity, analogous to that between water and molasses. By means of this flow, iron and many other metals may be rolled into sheets, drawn into rods or wires, or hammered into various desired shapes by skilful workmen. Here is a core-chuck, which can be put into a turning lathe, for shaping a flat disk of metal into a hollow vessel. As the chuck revolves, a gentle steady pressure causes the flowing particles to adjust themselves to its sides, so that, by having proper cores, we can "spin" bowls, vases, teapots, creamers, and various useful or ornamental dishes with great rapidity.

After the vessel is spun, it may be prepared for ornamenting by vibrations and flow of another kind. You remember the beautiful "repoussé" work in many of the departments of the Exhibition, and some of you, doubtless, were curious enough to inquire how it was made. The old method was by simple, careful hammering from the back; but there was always danger of an unlucky blow, that would break the metal and ruin the work of many days or months. Here is a "snarling," or repoussé[1] iron, firmly fastened in a vice. Mr. Krider has kindly sent us one of his skilful workmen, who will show us the process of snarling. The floral or other design is drawn on the outside of the vessel, and you see that when Mr. Sloan hammers on the end of the snarler which is nearest the vice, the whole tool is set in vibration, and the rapid, gentle taps of the other end gradually raise a knot or snarl of the desired height and outline. After the snarling or repoussé work is done, the chasing process follows. The hollow is filled, as you observe, with a softish cement, which yields slightly to the pressure of the chisel or graver, or such other tool as the artist may select from this large assortment, and the design is thus wrought out into the beautifully finished details of stem and leaf, stamen and petal, and tendril and delicate veining.

Iron is fitted by its cheapness, strength, elasticity, malleability, ductility and plasticity, for general application to ornamental uses and for taking expressions in tracing and foliage such as no other material can supply. The processes which I have just explained, furnish an immense addition to the facilities of the artisan for the

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[1] The terms "spinning" and "snarling" seem to have been borrowed from the textile arts. The French word "repoussé," signifies "pushed back," indicating the mode of hammering.

expression of his thoughts, and make it the more wonderful, as well as the more deplorable, that the æsthetic treatment of wrought iron and steel should have become so nearly a lost art. In all parts of Europe there are many mediæval specimens of such treatment preserved, which are worthy of special study. Candelabra, grilles, railings, newels, balusters, crosses, brackets and rings for cornice poles, chapel screens, gargoyles, vanes, bolts, hinges, locks, keys and escutcheons, knockers, handles and rings for bells and doors, are decorated with *eisen-blumen* or flower-work of beaten iron, or with various tracery, both serious and grotesque. They display an exuberance of invention and judicious taste which are calculated to enhance our respect for the earnestness and thoughtfulness of the unknown workmen, whose resounding hammers so lastingly imprinted lessons of faith, hope and love.

In Germany, Bohemia, Switzerland, and especially in the Tyrol, men in armor, bears or other animals, skilfully wrought, and holding the flag of the district or canton, are often found in the public squares or market places. At Jensbach there are remains of ancient smelting works, and of a forge which seemed specially devoted to a peculiar symbolic teaching. The great gray stone houses of the village are adorned by emblems of love and social feeling, being nearly all protected by curious huge dolphins, which are, apparently, just on the point of flitting from the water-spouts. In nearly every village church or graveyard the artistic eye may be gratified by contemplating the taste displayed in a cross, or a rood screen, or an altar-gate, or a chandelier, or the ridge-cresting and terminals which wed the gothic architecture to the sky and landscape, as if with a fringed network of delicate lace on the delicate gray, and against the blue. Sometimes the rods of the screen are so arranged in perspective as to represent an iron-arched arbor, under which one must walk in traversing the length of the aisles. Sometimes the symbolism is made still more expressive by combining rich clustering vines with the intricate blossoms of passion flowers, displaying a wealth of tendrils and leaves naturally and gracefully entwining the palings of a simple or rustic gate; always the evidences of devout aspiration, childlike trust, deep feeling and loving labor, are such as to bring us into a reverent sympathy with the artists who sought to give visible utterance to some of the most universal and most far-reaching longings of humanity.

Near the west door of the Antwerp Cathedral is a well with gothic canopy and tracery of iron, surmounted by the statue of a knight in armor. It was executed, in 1480, by Quentin Matsys, "at one time a blacksmith, afterwards a famous painter," whose romantic history is briefly commemorated by the inscription on a neighboring tablet: "Connubialis Amor de Mulcebre fecit Apellem"—connubial love made an Apelles from a Vulcan. It is said, that this first "learned blacksmith" fell in love with a painter's daughter, and in order to obtain her for his bride he changed his profession, acquiring even greater reputation as a colorist than he had gained by his handiwork at the forge. In the knowledge of that universal language which rings so sweetly in the ears of youthful admirers, he set a precedent for the learned blacksmith of our own days; but, unlike his far-famed successor, he manifested no disposition to trace the universal language into all its dialects. His parity of success in his two vocations, shows that he had the fire of true artistic genius, and his fame may encourage the wielder of the hammer, as well as the sitter at the easel, to look for an ever-ready appreciation of whatever depth of thought finds expression through patient, faithful work.

It is a quarter of a century since the first London "World's Fair" revived a European interest in the capabilities of wrought iron for artistic uses. The progress of the revival is most strikingly exemplified in the Oxford Museum, which was erected in 1867, but traces of it are to be seen in all directions, about the modern public and private edifices of Great Britain, as well as in many of the churches. A notable example of good ecclesiastical work is the Hereford Cathedral Screen, which was shown in the International Exhibition of 1862, before it was removed to the place for which it was designed. Dr. Dresser speaks of it as one of the finest examples of artistic work with which he is acquainted. The grilles, altar-rail standards, and English fire-dogs, in the present Loan Exhibition of the Pennsylvania Museum and School of Industrial Art, placed, as they are, beside a pair of ornamental Florentine andirons of the 16th century, show that neither good taste nor skilful execution are wanting in the smiths of our day, and that an educated demand will call out work which may challenge comparison with anything mediæval. The pagoda-like pavilion of Messrs. Hart, Son, Peard & Co., with its great variety of contents, cast, woven, or hammered into "joys forever," justly claimed a large share of attention from the visitors

to the Main Exhibition Building, and in the Belgian department, Prosper Schroyer's door, with its wrought iron vines, grapes, and bunches of climbing flowers, furnished more food for thoughtful study than the rich laces and costly embroideries which surrounded it.

Our own city already shows the effects of the revival, but, unfortunately, our most satisfactory ornamentation is imported. The magnitude and importance of the iron and steel interests in the Keystone State, should stimulate our ornamental designers, architects, and contractors, to a generous rivalry with their European brethren. Elkington's Helicon Shield showed admirable effects from working steel with other metals by "appliqué," inlaying, and repoussé; the Spanish, Moorish and Indian departments contained much successful punching, pressing, and damaskeening; the Russian electrotypes in iron, by the Jacoby process, gave a delicate surface-finish which might be often used artistically with great advantage; the plasticity of steel, through its capabilities of alternate softening and hardening, and the elasticity of its graceful shapes when finally and permanently tempered, were everywhere full of suggestiveness. Shields, suits of armor, weapons of war, knives, kettles, steel and iron jewelry, and other articles of personal or household decoration, were well represented, most of them adorned with traditional and conventional embellishments which have been handed down from a remote antiquity. Let our wise designers study such examples; let them cleverly combine the different ways of working and different styles of ornature; let them learn from the worker in bronze, the goldsmith, and the jeweler, new devices to charm the eye and elevate the imagination; and their field of labor will be so much enlarged that they will seem to have invented a new industry.

I have spoken of the symbolical thought which was so generally expressed by the iron-workers of the cinque-cento. How can it be better revived and expanded than by taking lessons from the old schoolmasters of Eastern Asia, "these from the land of Sinim?" The gipsy kettle, as it is often called, the common bulged tripod dinner-pot, which is used the world over, is copied from Chinese incense-burners that were in use more than five thousand years ago. The Chinese have long had a mania for collecting old bells and vases, partly from their universal reverence for antiquity, partly for the severe simplicity of outline and garniture by which the articles are generally characterized, partly for their moral lessons and associations.

A motto from Confucius, or a line of wise advice from some other favorite author, is commonly cast, stamped, or cut into the bronze; the "all-seeing eye," under various modes of conventional treatment, looks from the outer surface, even as it looks from the amulets and edifices of Egypt and Yucatan; the three feet are said to represent the three guardian spirits that watch over the Emperor, the nobles, and the people. Nearly all the old metallic vases have a special history, independent of their antiquity, for it has been a practice from time immemorial, to use them as presents from princes and nobles, and men of wealth or station, to those whom they wished to honor. In the magnificent and unique collections of cloisonné enamels which adorned our Centennial, the delicate filigree, and the richly variegated hues of the cellular glazing, seemed to be lavished with a peculiarly loving tenderness, on the old homely and homelike form which we all know so well. Our workmen enamel iron skilfully for common purposes; who doubts that they might rival their almond-eyed brethren in applying the art to æsthetic purposes, if they were rightly encouraged? Any ornamentation upon articles of daily use, especially if it be symbolic, or otherwise suggestive of high ideals, may become a source of continual gratification and of constant ennobling instruction.

I can think of no decorative process that has ever been employed upon any metal, which is not equally suited for iron; indeed I doubt whether there is one which has not been repeatedly and successfully tried upon that most precious metal. A judicious renaissance may lend new force to the Jewish legend which has been so well illustrated, by Schuessele with his brush, and by Sartain with his burin. The story runs, that when the temple was finished, Solomon gave a feast to his artificers. On unveiling the throne, a blacksmith was found in the seat of honor, on the right of the king's place. The people clamored, and the guards wished to cut him down, but Solomon commanding him to speak, he said: "Thou hast, O king, invited all craftsmen but me, yet how could these builders have raised the temple without the tools I furnished?" "True," answered Solomon, "the seat is his of right. All honor to the iron-worker."

[The lecture was illustrated by practical repoussé working, chasing, and lantern pictures of Centennial exhibits, furnished by the Centennial Photograph Company.]

Award of Prizes.—The *Annales des Ponts et Chaussées*, for Jan., 1877, announces the following awards, made Dec. 16, 1876, to the authors of the best memoirs published in the *Annales* in 1874, viz.:

Gold medal of 600 francs to M. Hirsch, for his "Theory of aerothermic engines."

Three gold medals of 500 francs:

1. To M. Malézieux, for his "Report on the English Railways in 1873."

2. To M. Choron, for his "Note upon the calculation of the bending moments and the flexures in straight metallic beams with many bays."

3. To M. Malézieux, for his "Memoir on foundations by compressed air.

Two honorable mentions:

1. To M. Schlemmer, for his "Notes on the present state of jurisprudence in the matter of setting the limits of water courses in the public domain."

2. To M. Felix Martin, for his "Notes on the works of Adam de Crapponne." C.

The New French Postage Stamps.—Abbé Moigno[1] severely criticises these stamps: In an artistic view, the two Liliputian and half-naked figures, which stretch their arms over a kind of altar, while their legs look as if they were trying to cut capers, are simply ridiculous. In mechanical execution, the impression is bad, and it is said that a passable success was obtained only after innumerable failures. The inks, also, are badly chosen. The small stamps are all of a dirty green, and to distinguish them from one another it would be necessary to examine them very closely if the figures, 1, 2, 3, 5, were not large. The size of the figures is the only advantage of the new stamps over the old, and this gain is more than counterbalanced by an awkward clumsiness. In a country like France, where so many persons cannot read, the similarity of tints is a source of many mistakes and frauds. C.

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[1] *Les Mondes*, Feb. 1, 1877.

JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

Vol. CIII. JUNE, 1877. No. 6.

EDITORIAL.

Notice.—The publication of the Journal is made under the direction of the Committee on Publication, who endeavor to exercise such supervision of its articles, as will prevent the inculcation of errors or the advocacy of special interests, and will produce an instructive and entertaining periodical; but it must be recognized that the Franklin Institute is not responsible, as a body, for the statements and opinions advanced in its pages.

Franklin Institute.

Hall of the Institute, May 16th, 1877.

The stated meeting was called to order at 8 o'clock P. M., the President, Dr. R. E. Rogers, in the chair.

There were present 149 members and 20 visitors.

The minutes of the last meeting were read and approved.

The Actuary presented the minutes of the Board of Managers and reported that at the last meeting 19 persons were elected members of the Institute; that on the recommendation of the Committee on Science and the Arts, the Board awarded the Elliott Cresson Gold Medal to Mr. P. H. Dudley, for his Dynograph for measuring and graphically recording Railway Resistances; and that the following donations were made to the library :

Catalogue of the University of Penna. 1876-77. From L. M. Haupt, Prof. Civil Eng.

Brazilian biographical annual, by J. Manuel de Macedo. Vols. 1–3. Rio de Janeiro, 1876. From the Smithsonian Institution.

Sixty numbers of the JOURNAL OF THE FRANKLIN INSTITUTE, from 1871-75 incl. From Wm. P. Tatham. Philad.

Bulletin of the United States Geological and Geographical Survey of the territories. Vol. 3, No. 1. Wash., April 5, 1877. From the Department of the Interior.

Annual report of the chief of the bureau of statistics on the commerce and navigation of the United States. 1861–63 and 1865–75 incl. Wash. From Hon. Chas. O'Neil, House Rep.

Dana's text book of mineralogy with an extended treatise on crystallography and physical mineralogy. N. Y., 1877.

Elements of geometry, by G. M. Searle, with an appendix containing problems and additional propositions. N. Y., 1877. From Wiley & Sons, N. Y.

Hydraulics of great rivers, by Révy, J. J. London, 1874. From the Friends' Library, Germantown, through their librarian, Wm. Kite.

Specifications and drawings of Patents issued from the United States Patent Office, for October, 1876. Wash., 1877. Report of the Com. of Pat. for the year 1863. Vol. 1. Wash., 1866. From the U. S. Patent Office.

Contributions to the Centennial Exhibition, by John Ericsson. N. Y., 1876. From the author.

Foundation of the Washington National Monument, Reports on. From the Engineers' Office.

Quarterly weather report of the Meteorological Office. Pt. 3. 1874. London, 1877. Charts of meteorological data for nine Ten degree squares. Lat. 20° N. to 10° S., Long. 10° to 40° W. Remarks to accompany the above. From the Meteorological Committee, London.

Chemical and physical researches, by Thos. Graham. Edinburgh, 1876. From Young & Smith. Edinburgh.

The Secretary reported from the Committee on Science and the Arts, that at its last meeting it recommended the award of the Scott Legacy Premium and Medal to Thos. Shaw, for his spiral exhaust nozzle; and the Elliott Cresson Gold Medal to John Charleton, for his internal clamp coupling.

The Secretary presented his report, embracing the following subjects: an illustrated description of the Steam Street Car invented by Mr. Louis Ransom (Troy, N. Y.), six of which are now running on the Market Street line in this city; films of gold, prepared by Mr.

A. E. Outerbridge, having the extraordinary thinness of about one-three millionth of an inch; examples of remarkable corrosion of the propellor blades of Trans-atlantic steamers; the Edson electric pen and duplicating press; Russell's parallel pliers; J. B. Shannon's bran duster; J. W. Moyer's adjustable bed bottom, and a note from Mr. H. W. Pond, upon the sticking fast of the safety valve of a steam boiler under peculiar circumstances.

The Secretary read a letter from Mr. A. T. Goshorn, Director General of the late Centennial Exhibition, conveying a copy of the Report of the Judges, upon which a medal was awarded to the Institute "for its interesting exhibition, and for its valuable contributions to the progress of the Arts and Sciences."

The following letter, referred to this meeting by the Board of Managers, was read:

FRANKFORD, April 20th, 1877.

FRED'K FRALEY, Esq.

My Dear Sir:—I am permitted by my nephews, John and William Struthers, to present to the Franklin Institute a marble bust of William Strickland, deceased, who was (I am informed) the first secretary of the Institute. My father and Mr. Strickland were co-workers and life-long friends, and both among the early promoters of the Institute. I now desire that these memorials[1] of them, should become the property, and remain together in keeping of the Institute, which they, when living, so highly esteemed. Will you be kind enough to request the acceptance of the bust by the Board of Managers?

Yours, very respectfully,

JOHN STRICKLAND STRUTHERS.

On motion of Mr. Hector Orr it was

Resolved, That the gift to the Institute, by Mr. John Strickland Struthers, of the bust of the late William Strickland, Esq., be gratefully accepted, and the Board of Managers be requested to make such arrangements as may be necessary to receive and care for the same.

On motion, the meeting adjourned.

J. B. KNIGHT, *Secretary.*

Cosmical Dust.—M. Daubrée accounts for the smoky or dusty clouds, which often remain after the disappearance of meteors, and for the masses of dust which often pervade the atmosphere, by explosive action under great pressure. C.

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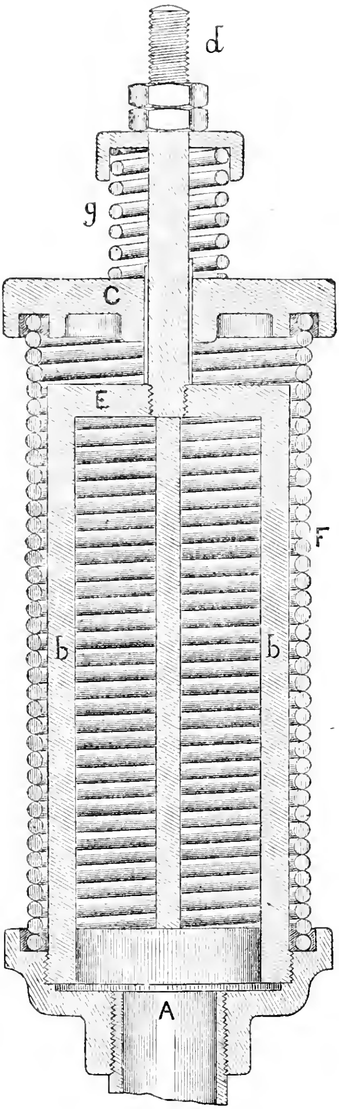
[1] See minutes of Dec. 20th, 1876, p. 9, this vol.

SHAW'S SPIRAL EXHAUST NOZZLE.

Extract from the Secretary's Report, at the Meeting of the Franklin Institute, Feb. 21st, 1877.



The great danger and annoyance arising from the safety valves of locomotives and steamboats are familiar to all, and are often so great as to imperil life as well as property.

When a train of cars is standing at a station, the roar of the safety valve is so deafening that it prevents the rapid transaction of business, and causes great annoyance and fright to passengers.

When a tug-boat is going alongside of a vessel to make fast, or is making a landing with a vessel, the stopping of the engines necessitates the raising of the safety-valve, and the escaping steam produces such a howl that orders cannot be heard, and, consequently, not executed with that promptness necessary to safety.

Especially is this the case with vessels in foggy weather, when listening for sound signals from shore, or in case of threatened collision, when a few moments' delay may cost lives, as well as loss of property.

The spiral exhaust nozzle of Mr. Thos. Shaw, is intended to quiet all this noise, while allowing the free escape of steam.

The construction of the nozzle will be easily understood by referring to the accompanying cut, which shows a

vertical section through the centre. *F* is a cylindrical coil of wire of such diameter and length that, when compressed nearly to contact, the aggregate area of the spaces between the turns of the coil, is much greater than that of the escape pipe. The bars *b b*, support the coil in a vertical position, between two plates *A* and *C*, and it is held in compression, nearly to contact, by the bolt *d*, which also admits of adjustment of the spaces in the coil. The spiral spring *g*, is introduced between the plate *C* and the nuts on the bolt *d*, so as to permit a slight increase of the spaces in the coil, should the pressure on its interior become too great. The base plate *A*, is attached to the end of the pipe through which the steam enters the nozzle, and the coil takes up the vibrations, which would otherwise be transmitted to the air by the escaping steam. As, however, the individual turns of the coil cannot vibrate to any considerable extent without coming in contact with the adjacent ones, interference occurs to such an extent that the vibrations are not transmitted to the air.

A report adopted by the Committee on Science and the Arts, of the Franklin Institute, says:

" We have examined the apparatus and tested its merits, in quiet-" ing the noise produced by steam escaping from the safety-valves of " boilers, and find that it accomplishes the object most effectively;" and concludes: "In view of the annoyance, fright and danger, " arising from the roar of escaping steam, and of the completeness " with which the nozzle destroys this roar, we are of the opinion that " Mr. Shaw has done a great service to the community, and particu-" larly to the transportation interests, in overcoming an obnoxious " and dangerous feature in the use of steam; and we recommend the " award to him of the Scott Legacy Premium and Medal, for his " spiral exhaust nozzle."

This nozzle is strongly indorsed, and its use recommended, by the Board of Supervising Inspectors of steam vessels, by owners and captains of tug-boats, and engineers in the navy, and has recently been fitted to all the American line of steamers. K.

Organic Phosphorescence.—M. T. L. Phipson has been studying the phosphorescence of various organic compounds, and he finds that *noctilucine*, a nitrogenous body extracted from fireflies and glow-worms, becomes luminous by slow oxidation, like phosphorus in the mineral kingdom. C.

TRANSPARENT GOLD.

Extract from the Report of the Secretary, at the Meeting of the Franklin Institute, May 16th, 1877.

In the course of a lecture on gold, delivered before the Franklin Institute, on February 27th last,[1] Mr. A. E. Outerbridge, Jr., of the Assay Department of the Mint in this city, gave an account of some experiments he had made, with the view of ascertaining how thin a film of gold was necessary to produce a fine gold color.

The plan adopted was as follows: From a sheet of copper rolled down to a thickness of $\frac{5}{1000}$ of an inch he cut a strip $2\frac{1}{2}$ by 4 inches. This strip, containing 20 square inches of surface, after being carefully cleaned and burnished, was weighed on a delicate assay balance. Sufficient gold, to produce a fine gold color, was then deposited on it by means of the battery; the strip was then dried without rubbing, and re-weighed, and found to have gained one-tenth of a grain, thus showing that one grain of gold can, by this method, be made to cover 200 square inches, as compared to 75 square inches by beating.

By calculation, based on the weight of a cubic inch of pure gold, the thickness of the deposited film was ascertained to be $\frac{1}{980400}$ of an inch, as against $\frac{1}{367650}$ for the beaten film.

An examination under the microscope, showed the film to be continuous and not deposited in spots, the whole surface presenting the appearance of pure gold.

Not being satisfied, however, with this proof, and desiring to examine the film by transmitted light, Mr. Outerbridge has since tried several methods for separating the film from the copper, and the following one has proved entirely successful:

The gold plating was removed from one side of the copper strip, and by immersing small pieces in weak nitric acid, for several days, the copper was entirely dissolved, leaving the films of gold, intact, floating on the surface of the liquid. These were collected on strips of glass, to which they adhered on drying, and the image of one of them is here projected on the screen, by means of the gas microscope.

You will observe that it is entirely continuous, of the characteristic bright green color, and very transparent, as is shown by placing

[1] See JOURNAL OF THE FRANKLIN INSTITUTE, Vol. ciii, p. 281.

this slide of diatoms behind the film. By changing the position of the instrument, and throwing the image of the film on the screen by means of reflected light, as is here done, you will see its true gold color.

Mr. Outerbridge has continued his experiments, and, by the same processes, has succeeded in producing continuous films, which he determined to be only the one-two million seven hundred and ninety-eight thousandth ($\frac{1}{2798000}$) of an inch in thickness, or ten thousand five hundred and eighty-four (10,584) times thinner than an ordinary sheet of printing paper, or sixty (60) times less than a single undulation of green light. The weight of gold covering 20 square inches is, in this case, thirty-five-thousandths ($\frac{35}{1000}$) of a grain; one grain being sufficient to cover nearly 4 square feet of copper.

As you see, the film is perfectly transparent and continuous, even in thickness, and presents all the characteristics of the one shown before. That a portion of the image appears darker, is due to superposed films, the intensity of the green color being proportioned to the thickness through which the light passes.

These experiments will give new interest to the question of the cause of gold appearing green by transmitted light. K.

White Cement.—Herr O. Fahnejelm recommends a mixture of 75 parts of carefully washed chalk and 25 parts of washed kaolin, to be first calcined to red heat and afterwards ground. The powder is then snow-white, or, if the heat has been too great, it has a bluish shade. Either alone, or with a small percentage of gypsum, it makes an excellent hydraulic cement.—*Dingler's Polyt. Jour.*, 223, 3. C.

Secondary Elasticity.—In a late number of *Poggendorff*, Ferdinand Braun[1] reports a series of experiments with metallic rods, wires, threads and gums, in continuation of the experiments of Weber, Kohlrausch and Boltzmann, upon the after effects of elasticity. The independent and combined influences of bending, tension and stretching are investigated at considerable length, the results presented in eighteen tables, and a variety of fundamental propositions deduced which seem likely to have important bearings in chemical and other molecular investigations. C.

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[1] *Ueber die Natur der elastischen Nachwirkung.*

Mechanical Stoking.—A paper was recently read at the Society of Engineers by Mr. J. Walter Pearse on the "Mechanical Firing of Steam Boilers." The author first pointed out some of the disadvantages of hand-stoking, and observed that so far back as 1813, mechanical firing was proposed. In 1822, Mr. J. Stanley invented a stoker with crushing and rollers a single horizontal fan, to which, in 1834, he added rocking fire-bars. In 1838, Mr. Juckes patented his first stoker, and in 1841, he invented the endless chain of fire-bars, modifying it again in 1842. In 1863, Messrs. Wilson and Smith brought out their furnace, in which the fire-bars were made to travel backwards, carrying the fuel from a hopper to the back of the grate, an arrangement which was improved upon by Messrs. Vicars and Smith in 1867. In 1870, Mr. Dillwyn Smith patented his stoker, in which the fuel is fed on to distributing fans revolving horizontally. This arrangement was improved upon, in 1870, by Mr. J. F. Deacon. Further additions were subsequently made by Mr. T. Henderson. In the Henderson stoker the supply of fuel is effected in the same way as in the Dillwyn Smith machine, but the fire-bars are made to move by simple gear connected with the stoker. Every other bar rises and falls, while the rest slide to and fro, the effect of this action being to clear off the clinker. The Frisbie feeder improved by Mr. J. M. Holmes, is for slow combustion and intermittent feed. The coal is thrust up underneath, and in the middle of the fire, so that the gases evolved are consumed on passing through the incandescent mass. This stirs the fire and propels all clinker to the circumference of the circular revolving grate. Mr. Holroyd Smith's "Helix" fire-feeder gives a continuous feed from below, by means of a screw working in a casing connected at its upper side with a trough which takes the place of one or two fire-bars.—*Journal of the Society of Arts.*

Carbonic Acid in Sea-Water.—O. Jacobsen has found large quantities of carbonic acid in sea-water, which can be removed only incompletely and with great difficulty, even by heating in a vacuum. He attributes the fact to a peculiar action of the magnesium chloride and calcium carbonate which are dissolved in the water. C.

Zinc in Animals and Vegetables.—MM. G. Lechartier and F. Bellamy have found zinc in the liver of men and calves, in beef, in hens' eggs, and in the grains of wheat, barley, maize, beans and lentils. C.

DIVISIBILITY OF ELECTRIC LIGHT.

By MM. L. Denayrouze and P. Jablochkoff.

Although the invention of M. Paul Jablochkoff has been in continual progress since the first communication which I had the honor of presenting to the academy, I have thought fit to wait before calling further attention to our studies, until a decisive application should have publicly and practically shown:

1. That the fixed light (*bougie*) could advantageously replace the regulator. 2. That it is possible to obtain by this process, many luminous centres with a single source of electric currents.

We have just established these points beyond controversy, by lighting, with multiple centres, every evening of the past week, one of the principal halls of the Louvre.

After this public verification of the principle submitted to the academy, I venture to announce the important result lately obtained by M. Jablochkoff, during some months of investigations, pursued in the workshops of the society which I direct.

From the first experiments upon the fixed light, we perceived that if we obtained by its means a steadier light than with the regulator, and if we could at the same time produce many illuminating centres, this double result was due to the action of the current upon the insulating material interposed between the two carbon points. The voltaic arc, by fusing this substance, established, for the current, a much easier passage between the points than when the insulator was solid. Experiment showed that when a certain tension was given to the current, the distance that the current could leap over this sort of liquid conductor, became sufficient to produce a considerable number of illuminating centres. We have thus obtained as many as eight bougies burning at once in the circuit of a single machine, with reciprocating currents, of the most ordinary type.

M. Jablochkoff then tried the effect of sparks, produced by a current of great tension, upon refractory bodies.

He introduced in the central circuit of the machine, the interior wire of a series of induction coils, and caused the spark from the induced current to pass over a sheet of kaolin, placed between the two extremities of the exterior wire of each coil.

We then saw that, although the current had not enough intensity to melt the interposed kaolin, it heated it to incandescence.

The current is first made to pass over a better conductor, arranged on the edge of the kaolin sheet. The part of the plate which is thus heated, forms a line which becomes a conductor of great resistance, and which, upon the passage of a current of great tension, glows with the heat and emits a beautiful light. Over the whole length there is a slight consumption of kaolin, at the rate of about one millimetre per hour. There is thus formed, between the two extremities of the coil, a magnificent luminous band, which may reach a much greater length than the induction spark ordinarily produced by the same coil. But this luminous band, in place of being slightly luminous, like the induction spark, is a permanent focus, giving a light which is soft, and steadier than any other known light. Its power depends on the number of windings and the diameter of the wire employed in the coil.

As a large number of bobbins may be placed in the circuit, and as each bobbin may be divided into numerous sections separately illuminating kaolin bands of suitable length, we thus obtain a complete divisibility of the electric light. We can very easily get fifty luminous centres of a variable intensity.

In our experiments we employed bobbins of different sizes. The intensity of the focus corresponding to each one of them, varies naturally with the dimension of the bobbin. We scaled the intensities of the different foci, so as to have a graduated series of luminous bands, of which the most feeble give a light equivalent to one or two gas-burners, and the strongest a light of fifteen burners.

In employing the alternative currents, the break and the condenser may be suppressed; then the whole system of distribution of the currents is reduced to a central artery, represented by the series of interior wires of the bobbin, from which branch out as many distinct conductors as there are bobbins in the circuit. Each luminous centre is thus perfectly independent, and each of them may be extinguished or lighted separately. The distribution of electricity in a building which is to be lighted, becomes then analogous to the distribution of gas, and in the special factory which we are constructing, the largest rooms will be lighted by bougies, the offices and corridors by bands.

The following are the results which M. Jablochkoff has already attained: 1. Complete divisibility of the electric light. 2. Absolute

steadiness of this divided light. 3. Possibility of distributing in any proportions, and in any points of a place which is to be lighted, great, small or medium lights. 4. Dispensing with carbon points for the small and medium lights.—*Comptus Rendus*, April 16. C.

Action of Compressed Incandescent Gases.—M. Daubrée has been experimenting upon the combustion of powder in close vessels, obtaining results which seem to account for the alveolar surface of meteorites as well as for a variety of volcanic and other geological phenomena. A rectangular plate of steel having a surface of 23 square centimetres, and weighing 3·479 grammes, was placed in a closed vessel, which had a capacity of 43 c. centimetres. The plate was rolled so as to be completely surrounded by the gases which resulted from the explosion of the powder by the electric spark. The deflagration lasted less than ·02 of a second. The gases acquired a tension of from 1000 to 1500 atmospheres, according to the charge employed, and an estimated temperature of more than 2000° C. The cooling was equally rapid, on account of the enormous difference between the gaseous temperature and that of the walls. In an experiment with 12 grammes of powder, the steel plate was entirely melted, and transformed into a spongy ingot, curiously distorted and puffed up, like the ferruginous skeleton of some meteoric stones. At the same time, nearly a fifth of the iron was reduced to a sulphuret, in the form of an impalpable powder. When a small opening was made in the chamber, so that a portion of the gases could escape with great velocity, sinuous furrows were scooped out of the sides of the iron vessel, a second aperture of escape was made at about 50° from the first, and a quantity of irritating metallic dust, in an incandescent state, was forced into the atmosphere. The effects were comparable, in their nature, suddenness and energy, to those which are produced by a thunderbolt, or a powerful electric spark.—*Comptes Rendus*, Mar. 5, 1877. C.

Spectrum of Electric Light.—M. P. Desains finds that the spectra of electric light are very similar to those of the solar rays. They are less extensive, particularly on the side of the violet; but the curves of intensity exhibit but slight differences in the region of greatest heat. C.

Algeria.—The February number of the *Annales des Ponts et Chaussées*, contains an interesting article on the natural conditions, the system of colonization, and the public works of Algeria. The plantations are among the most important elements of colonization. When they are not absolutely indispensable for sanitary purposes, as at Boufarik, and in all the marshy districts, they are valuable for their shade. The magnificent promenades of Tlemcen, Sidi-Bel-Abbès, and Blidah, show what can be done under great discouragements. In all the province of Oran, a few points excepted, the soil has a depth of only 10 to 15 centimetres. Each tree costs about 6 francs, and 2 francs a year for watering and care. The kinds most used are the plane, the elm, the acacia and the pine. The eucalyptus is also used, but it succeeds only in thickets. The plane is the most desirable wherever there is a sufficient supply of running water; it gives the largest shade, and forms the most magnificent arcades. The elm requires less watering, but its growth is slow. The acacia grows more rapidly, and thrives with still less water, but it is brittle, and must be shielded from the winds. The Aleppo pine needs little care, but it cannot be used for the public promenades. It is only planted in thickets, or upon large surfaces. The mountain of Santa Cruz, at Oran, and the sand dunes of La Macta, have been successfully planted with pines. The principal fruit trees are the orange and the lemon; when well watered, their fruit is abundant, and larger, if less delicate, than those of Spain and Malta.

The public works, harbors, railroads, reservoirs, canals, highways, villages and plantations—and the guardianship of the colony until its majority—involve heavy charges. Africa costs more than it pays, but the profitable harvest may-be near at hand. In 1830, Algeria was a land uncultivated, scantily supporting 3,000,000 inhabitants, without harbors, without roads, without water, continually wasted by famine and intestine wars. After a half century's occupation, thanks to European activity, improved culture, irrigation and safety of communication, barren steppes and uninhabitable bogs have been rendered wholesome, occupied and fertilized. Wheat, maize, tobacco, the vine and garden vegetables, have replaced the sterile palm-tree and the thorny jujube. The cost of living is only half as great as in France; the export, both of grain and of cattle, is considerable. The Arabs, divided, enclosed in the network of civilized centres, abandon the idea of resistance, and accept the neighborhood of the

infidel, which brings them security, the stir of business, and wants which require labor for their satisfaction.

The impression of a traveler who visits Algeria, is surprise; he is astonished at seeing France, with its inhabitants, its customs, and its very aspect, in a country which he expected to find purely Arabic. The time is not far distant when the colonists will have passed from their period of tutelage; then the charges will cease, and the product of the imposts, insufficient to-day, will increase in proportion to the rapid augmentation of the resources. The mother-country will be rewarded for her sacrifices. The austere definition of Sallust is no longer correct: by the omnipotence of labor and of science, the "inhospitable coast" has acquired harbors of refuge, the "cursed land" has been blessed with water and trees. It has become a part of France, and, perhaps, one of its richest districts. C.

Submarine Detonators.—In a report of Capt. Kunkler, on the successful removal of wrecks from the mouth of the Loire, the detonators are fully described. The primings were furnished by Capt. Putot, who prefers iridized platinum to pure platinum, because its coefficient of electric conductivity is, like that of most alloys, less variable with temperature. When the platinum thread is soldered in place, it is wrapped with a small tuft of dry gun-cotton, and the whole is protected by an envelope of paper glued on the stem of the primer. The battery liquid was a solution of 5 parts bisulphate and 1 part chloro-chromate of potash in 120 parts (by weight) of water, the solution being made at the moment of need. The liquid is poured into a cylindrical vessel of gutta-percha, of an interior diameter slightly greater than that of the gutta-percha plunger. As the plunger nearly fills the vessel, a small quantity of liquid suffices to moisten the zinc and carbon. The solution produces currents of about the same force as those of the sulphuric acid and bichromate of potash battery. Its only advantage is the dispensing with sulphuric acid, the transportation of which is always inconvenient. There were two failures—the first being due to the breakage of one of the wires, the second to a leakage, which was attributed to a softening of the rubber luting by exposure to heat. In the successful trial the joints were first luted with red lead, and then covered with leaf-rubber glued with liquid-rubber.—*Ann. des Ponts et Chaussées*, Feb., 1877. C.

Wood Preserved by Injecting Tannate of Iron.—M. Boris recommends Hatzfeld's process, which is based on an ingenious idea. The tannate of the protoxide of iron, which is soluble, absorbs oxygen rapidly from the air, and is transformed into insoluble tannate of peroxide. The operation is twofold: 1st, Injection of tannic acid; 2d, injection of a protoxide of iron. For this purpose pyrolignite is used, which combines the advantage of cheapness with that of not injuring the woody fibres. The injection is made in close vessels, with the same apparatus as for creosote. The inventor claims the following advantages: 1st, The complete insolubility of the tannate of peroxide, seems to give a complete guarantee of durability; 2d, the injection is so made as to yield a great excess of tannic acid, which, being free, coagulates the albumen of the wood, tanning it, so to speak, and transforming all woods into a kind of oak, very rich in tannic acid. C.

Reservoirs of the Rio Rimac.—The reservoirs are designed to prevent the havoc caused by the torrents during the rainy season, and to furnish a water supply, during the dry season, to the valleys and to the cities of Callao and Lima. They are situated in the cordillera of Huarochiri. They employ nine lagoons, at heights between 4287 and 4867 metres; but in spite of the great elevation the climate is so mild that the lagoons never freeze. The frequent alternations of frost and rain, the continual heavy thunder storms, the atmospheric oxidation of the rocks, the often terrible earthquakes, and the great danger which would result from the sudden precipitation of 36,000,000 cubic metres of water upon the city of Lima, forbade the employment of ordinary masonry for the dikes. A careful reconnoissance showed that it would be sufficient to make a narrow but deep trench for each of the lagoons, which could be closed by a metallic gate or dam supported at the sides by piers of masonry which are grooved into the living rock. The gate is formed of iron plates supported by horizontal beams. The difficulties of transportation require that none of the pieces shall weigh more than 150 kilogrammes. At the lower part of this metallic wall openings are made, bounded by squares in which the water gates play, under control of an operator at the top of the dam. The groove irons are Z shaped; the water gates are convex, to avoid too great thickness. All the iron, which is of the best quality, has been furnished by the Creusot workshops.

The piers are of cut stone, their dimensions varying with local circumstances. All the masonry has been very carefully executed. The stones are granitic, of large dimensions and so laid as to break joints in all directions. Native lime is used with Roman cement imported from England. The greatest depth of reservoir is 16·5 metres, the greatest capacity, 20,896,000 cubic metres. C.

Velocity of Light.—The 13th volume of the "Annales de l'observatoire de Paris," contains the memoir of M. Cornu on the determination of the velocity of light, embracing a complete recital of the experiments made in 1874 between the observatory of Paris and the tower of Montlhéry. Everything was done to obtain the greatest possible precision, by perfecting the method of the toothed wheel, which was devised by Fizeau in 1849. The method of observation, the construction of the various articles of apparatus and their mode of acting have been discussed in their most minute details, with a view to ascertain the causes of error, and to determine the most favorable conditions for their elimination. The agreement of results obtained under the most varied circumstances, shows the importance of this discussion. Care was taken in all cases to prove that the deviations followed the law of accidental errors, a verification which is commonly neglected, but without which the calculus of probabilities cannot be legitimately applied. The result of the experiments gives, for the velocity of light, 300,400 kilometres per second. This gives for the solar parallax, $8{\cdot}88''$, if we adopt Delambre's equation of light, ($493{\cdot}2^s$) or Bradley's constant of aberration, ($20{\cdot}25''$), $8{\cdot}80''$, with Struve's constant, ($20{\cdot}445''$).—*Les Mondes*, March 8; *Acad. des Sciences*, Feb. 26. C.

Pantopollite.—At the dynamite factory of Opladen, a cheap kind of dynamite is made which is called pantopollite. It contains a certain percentage of nitro-glycerine, dissolved in naphthaline, to prevent the production of troublesome nitric vapors at the time of the explosion. It has been tried at the mines of Friederichsthal, where the explosive effects were very satisfactory; but after the explosion, the fumes were so disagreeable that it was necessary to suspend the labor for some time, and the miners suffered from severe pains in the head and chest. Ten kilogrammes of pantopollite effected a more complete disaggregation, than thirty kilogrammes of common powder. C.

A New Kind of Nobili's Rings.—In *Poggendorff's Annalen* for November, 1876, J. Schiel[1] describes the formation of galvanic rings on a pure gold surface. In a small porcelain saucer, or in a watch glass, he places a small plate of absolutely pure gold, of about three centimetres diameter, and three grains weight. In its centre he puts a pointed platinum wire covered with lac or gutta percha, and connected with the positive electrode of from 4 to 8 galvanic elements, arranging an annular platinum wire around the gold plate, some millimetres higher. Filling the glass with distilled water, acidulated with a few drops of sulphuric or nitric acid, he connects the annular wire with the cathode, thus closing the circuit, and in a few minutes the gold plate takes a reddish color. Breaking the circuit after from 6 to 10 minutes he washes and dries the plate, which shows a number of palish concentric rings. If exposed for a few hours to direct sunlight, or to diffused light from 8 to 10 days, the rings assume a coloring, especially after the gradual exposure, of remarkable beauty and brilliancy. In the course of 6 or 8 weeks the colors are mostly changed into a dark bluish violet. If the gold contains the least portion of silver, the beauty of the rings is diminished, and they assume the violet hue. The central ring is commonly the most beautiful and characteristic. It exhibits, upon application of nitric acid, the whole spectrum, while the others show mostly only red, purple or green. By careful manipulation with an ivory spatula, the colors can often be changed, *e. g.*, from red to green, as if there were a green layer under the red. Similar, but less striking effects, may be produced with alkaline liquors. The play and changes of color which the rings give under the Nicoll's prism, are remarkably beautiful. Within twenty-four hours after the galvanic exposure of the plate, the polarized rings display their full brilliancy. C.

Marine Sounding-Line.—M. Ch. Tardieu employs a spherical envelope of caoutchouc, communicating with an iron reservoir by means of a small tube which is provided with a valve. The envelope being filled with mercury, any increase of external pressure forces into the reservoir some of the mercury, which cannot return on account of the valve. The weight of the mercury determines the pressure, and consequently the depth of the water. C.

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[1] *Ueber das galvanische Verhalten des Goldes und eine neue Art Nobili'scher Ringe.*

Civil and Mechanical Engineering.

STEAM ON STREET RAILWAYS.

Extract from the Secretary's Report, at the Meeting of the Franklin Institute, April 18th, 1877.

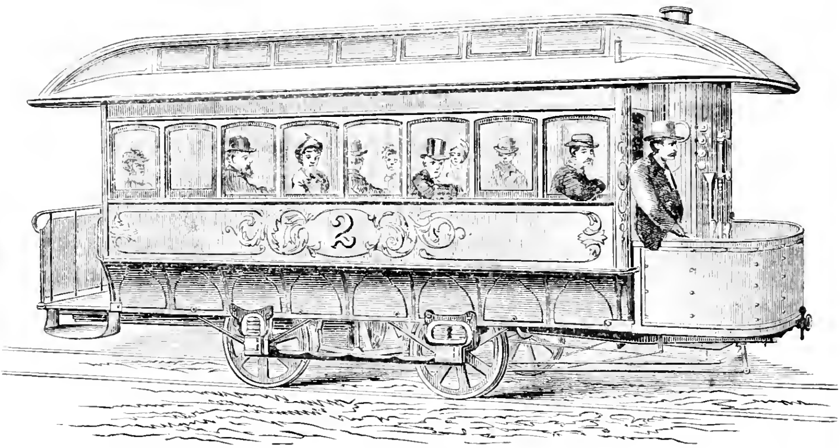
At the stated meeting of the Franklin Institute, for April, 1877, the Secretary called attention to the growing importance of the subject of steam propulsion on street railways, and stated his intention to present and illustrate, from time to time, the progress being made towards the successful accomplishment of this desirable object. He proposed commencing with what is doing in our own vicinity, and gave the following statement (accompanied by illustrations on the screen) showing the part which Messrs. Burnham, Parry, Williams & Co., proprietors of the Baldwin Locomotive Works, of this city, have taken in connection with this subject; together with some data regarding the comparative cost of running street cars, in this city, by horses and by steam.

The demand for some motive power other than horses for this purpose, is becoming very general and emphatic. Not only is great interest manifested in the subject in all parts of our own country, but also in South America, the West Indies and in Europe, public attention is strongly turned in this direction.

The advantages to be gained by the use of steam are, greater economy in operation, and greater convenience to the public. The greater economy is expected from the fact demonstrated in every other business requiring power, that the most economical artificial power is derived from a steam boiler. The economy of steam on street railways, it is believed by some, has already been demonstrated by actual experience. Sufficient data have now been acquired to give actual figures on which to base a calculation. The superior advantages derived by the public from steam on street railways, will be, in the steam cars being more manageable than horse cars; in their occupying less space in the crowded streets of a

city; in their being able to make their trips in shorter time (and this without running at a greater speed than horse cars), owing to the fact that they can be stopped and started much more quickly; and from the fact that, when steam is used, the greater speed obtainable will bring suburban localities practically nearer business centres.

In 1875 the Baldwin Locomotive Works became so strongly convinced of the growing demand for a better motive power than horses on street railways, that they concluded to build, at their own cost and risk, an experimental steam street car. The car was finished in November, 1875, and the following cut faithfully represents its appearance. The City Councils of Philadelphia were applied to for



permission to try the car in this city, and under an ordinance passed by Councils, permission was given for a trial of the car for three days on the West End Railway, of West Philadelphia. The trial was accordingly made, and the car worked satisfactorily. As three days were too short a time for an exhaustive trial, the proprietors of the Baldwin Locomotive Works next proposed to Mr. William Richardson, President of the Atlantic Avenue Railway, of Brooklyn (where permission to try steam had already been given), for an experiment with the car on his line. The arrangement was perfected and the car sent to Brooklyn December 25th, 1875. It ran in Brooklyn from that time until June, 1876. One engineer ran the car and kept it in working order. Its consumption of fuel was between 7 and 8 pounds of coal per mile run. It drew regularly,

night and morning, an additional car, with passengers going into New York in the morning and returning at night. On several occasions, where speed was practicable, the car was run at the rate of 16 to 18 miles per hour.

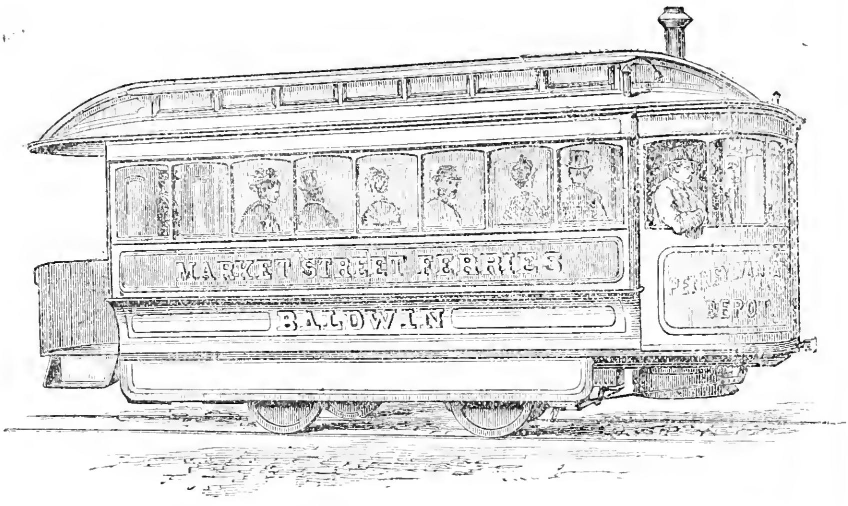
In June, 1876, this car was withdrawn from the Atlantic Avenue Railway of Brooklyn, and, by an arrangement with John S. Morton, Esq., President of the Market Street Railway, of Philadelphia, placed on that line. It worked with fair success and very acceptably to the public, on the Market Street line, from June till nearly the close of the Centennial Exhibition. Thousands of Centennial visitors were thus afforded an opportunity to witness the working of a steam car, and carried away impressions derived therefrom, which are doing much to promote the introduction of this form of motive power.

This original steam car was built with cylinders under the body of the car, the connecting-rods taking hold of a crank-axle, to which the front wheels were attached. The rear wheels of the car were independent, and not coupled with the front wheels. The machinery of the car was attached to an iron bed-plate bolted directly to the wooden framework of the car body. The experiment with this car demonstrated to the satisfaction of its builders, the entire practicability of the use of steam on street railways, but the defects developed by this experimental car were: first, that it was difficult, or impossible, to make a crank-axle which would not break; the same experience being reached in this respect, which had already presented itself in locomotive construction. Crank-axles in locomotive practice were abandoned in America many years ago, and are also disappearing in foreign locomotives. Second, it was found that great objection existed to attaching the machinery to the wooden car body, which was not sufficiently rigid for the purpose, and which suffered by being racked and strained by the working of the machinery.

For these reasons the builders removed this original steam car from the Market Street line in the fall of 1876, and placed it in their works to be re-constructed, in accordance with the experience which nearly a year's service had suggested. In order to remedy the trouble arising from the breakage of crank-axles, the machinery was made "outside-connected," the same as in an ordinary locomotive; and in order to obviate the defect found in attaching the machinery to the wooden car body, they designed and constructed a strong iron frame-

work, which should be entirely independent of the car body, and which should support the boiler and all the machinery.

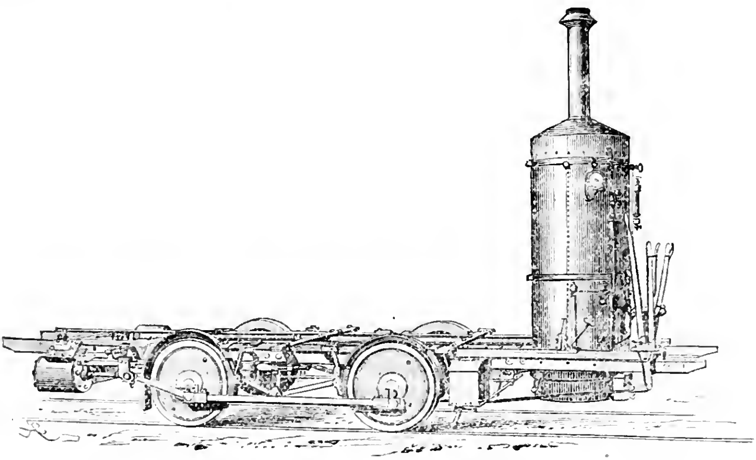
The car as thus reconstructed, was named the "Baldwin," and is shown by the following illustrations; one indicating the general appearance of the car in working order, and the other, the iron framework, carrying the boiler and machinery. This iron framework really constitutes a complete locomotive in itself, independent of the car body. It was finished and run by itself, without the car body being attached, on a trial at the Works. This design permits the use of existing cars, as the framework can be adapted to any car body. The cross-pieces shown in the cut support the body, which is held in position by three bolts on each side. Only the front



of the car where it adjoins the boiler needs any changing. The wheels are cast iron centres, fitted with steel tires, and are coupled by connecting rods on outside crank-pins. They are placed the same distance apart as the wheels of an ordinary horse car. The throttle valve is placed close to the cylinders, which gives the advantage of stopping and starting with great promptness. A powerful hand brake is provided, by which, with one motion of a lever, the engineer can stop the car in a few seconds. In addition to the brake, the engine can be reversed and back pressure used in case of emergency to arrest the motion almost instantaneously. The car is equalized on rubber springs with cross equalizing beams, and rides smoothly,

without any shaking or rough motion from the operation of its machinery. The boiler is of steel, double-riveted, and fully capable of carrying with safety a steam pressure of 300 pounds per square inch; only about 90 pounds pressure, however, is required to move it loaded over the heaviest grades on the Market Street line. It will thus be seen that every precaution in the interest of safety has been taken.

In conformity with an arrangement made with the President of the Company, the reconstructed steam-car "Baldwin" was placed on the Market Street line, March 21st, 1877, on the occasion of the trial trips made by the different steam-cars on that day. The maximum grades on this line are about four and one-half per cent., and up



these grades, and around the curves, in all weathers, and in all conditions of the track, the "Baldwin" has been run with entire facility, and without ever "stalling," or requiring assistance.

In order to determine the cost of the fuel, the coal consumed was weighed, as delivered to the car, for seven days. The aggregate quantity of fuel used was 4950 pounds for these seven days, during which the car made a mileage of 88 miles each day, or 616 miles in all. The average consumption of fuel was, therefore, 8·03 pounds of coal per mile run.

Four weeks' service of the "Baldwin" on the Market Street line terminated April 18th, and up to that date, the car had made 88 miles per day, and had run seven days in the week. It had never lost a trip, and at the date we speak of, occupied the same position on

the line as on the day it began service. It has required no repairs, except the ordinary care and attention from the engineers running it. The daily expense of running the car has been, therefore, as follows:

Total cost of fuel, per day, at 8 pounds per mile, 88 miles run, @ $4.00 per 2240 pounds, for anthracite coal, ...	$1.26
Oil, waste and tallow, per day, estimated, . .	0.25
Engineer, 16 hours per day, @ $0.25 per hour, .	4.00
Total cost, ...	$5.51

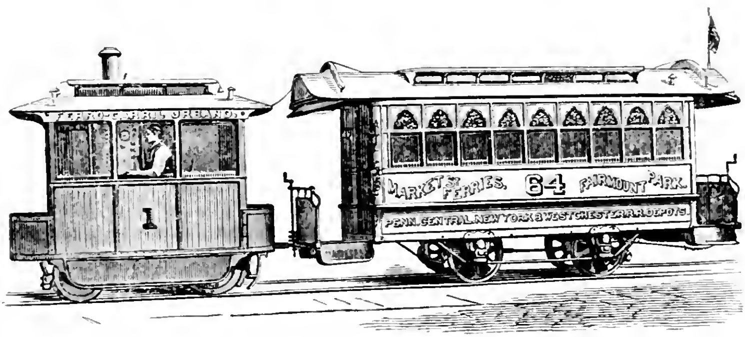
If to the above figures an allowance of one dollar per day is added, to cover depreciation and provide for future repairs, it is believed that the aggregate, $6.51, will represent fairly the cost of working a steam-car in the service described.

It should be noted that in this comparison the steam-car is placed on the same basis as a horse-car. This is of course unfair to the former, as it has ample capacity to run at three or four times the speed of a horse-car, and on suburban lines, therefore, the economy of steam would increase very rapidly. One Philadelphia Company, which works a suburban line with eleven horse-cars, has expressed the opinion that six steam-cars would do the same service.

We have thus far described only the steam-car, in which the boiler is combined with the car carrying the passengers. The Baldwin Locomotive Works early turned their attention to a separate motor, to which the ordinary cars could be attached, believing that in many cases economical and practical reasons would favor its use. The general principles involved in the separate motor are the same as in the steam car. Boiler and cylinders of equal capacity are used, and the machinery and wheels are all attached to an iron framework strongly braced. The entire weight of the boiler, machinery and water tanks, for a line with ordinary grades, is 12,000 pounds, which is no greater than the weight of a horse-car, when crowded with passengers. This is carried within the wheel-base, or the space between the two axles—thus doing away with all overhanging weight, front or back, and hence, with all rocking motion. The motor moves very steadily, and is, therefore, no more liable to damage the track than is an ordinary horse-car; in fact it is believed that by the steadiness of its motion, it is less damaging to the rails than a horse-

car. If steam is used in this manner, it will be seen that no changes whatever are required in the cars. The separate motor takes the place of two horses, and occupies the same space ahead of the car.

One of these motors was constructed in the fall of 1876, for the Citizens' Railway Company of Baltimore, the President of which line, Mr. John S. Hagerty, was quick to recognize the value and economy of this means of transit. The Citizens' Railway has maximum grades of seven feet per hundred, or $369\frac{6}{10}$ feet per mile. The service required by Mr. Hagerty, was that the motor should draw two loaded cars up this grade. The Baldwin Works constructed one machine, which was tried on the line, and was found fully capable of drawing one car, but with insufficient power for two. A second motor was accordingly built, which weighed about 16,000 pounds, and



which was sent to the Citizens' Railway in December, 1876, arriving there in the midst of the exceptionally severe snowstorms. During ten days' trial, it fully demonstrated its capacity to do the work required. It ascended the 369 feet grade, drawing one loaded car, when the tracks were covered with mixed snow and dirt to a depth of 8 to 10 inches in places. Where four horses were required to draw an ordinary car, the motor ascended the grade, drawing a loaded car without difficulty. As a result of this trial, the President of the company wrote on December 22d, as follows: "I have not tried it with two "cars, but it has had a test sufficient to guarantee us in taking it, so "far as climbing the hills is concerned. *It has gone up the grades "with one hundred passengers, on the worst day I have ever seen on*

"*our road.*" Subsequently the motor did its regular work and drew two cars without difficulty up the grade named. On several occasions, during the heavy snows of December and January, the motor was used to haul the sweeper for clearing the track, thus taking the place of from ten to fourteen horses, which were usually employed for the purpose. The city authorities of Baltimore, however, have not as yet granted permission for the regular use of this machine on that line, and it is therefore laid aside for the present.

Another and smaller motor, weighing only 12,000 pounds, was constructed about the same time for the Urbano Railway of Havana, Cuba. The illustration on the preceding page shows this machine. On its completion it was tried for some days on the Market Street line of this city, and drew one car regularly over the road, occasionally with as many as one hundred passengers. It worked with entire success, ascending the grades of 4½ feet per hundred, and was then shipped to Cuba. The results of its trial on the Urbano Railway of Havana, are given in the following extract from a report (translated) from the *Commercial Bulletin* of Havana, of November 9th, 1876: "The "machine which was to be tried, being attached to two cars, occu-"pied by some forty persons, drew them with a velocity which was "diminished or increased at the command of the conductor's bell, "stopping several times instantaneously without the slightest shaking "being noted in the cars. The experiment was made on different "occasions during the trip from the station of the 'Carmelo' to the "'Torreau de San Lazaro,' and each time, at the proper striking of "the bell, the same result was obtained. At its usual velocity, in "ascending a grade of two per cent. it can be stopped in three sec-"onds, and descending the same, in seven." It may be added that the consumption of fuel by this motor was found to be about the same as in the steam street car, viz.: eight pounds of coal per mile run.

Both of the motors above described were supplied with powerful steam brakes, by which the brakes could be applied instantaneously by opening a valve, admitting steam to the brake cylinder.

In conclusion, the following carefully prepared figures are presented, showing the economy of steam as compared with horse power, for street railway traffic. Apart from the superior facilities afforded the traveling public by steam, the saving which can be effected, is, of course, the practical question involved. In the following table, the calculations are made on the basis of statements and reports of various street railway companies in Philadelphia:

Cost of Running one Two-horse Car one Day.

For one car 9 horses are required; first cost (at $140), $1260.

Feed and stable expenses (feed, straw, hostlers, stable boss and medicines) of 9 horses, at 46 cts.,	$4 14
Shoeing of 9 horses, at 6 cts., ...	0 54
Maintenance of harness of 9 horses, at 2 cts., .	0 18
Maintenance of 9 horses (value $1260), at 33⅓ per cent. per annum for depreciation, equivalent per day for 9 horses to	1 15
Maintenance of car, ...	0 40
Wages of driver, ...	1 75
Daily interest on cost of car ($1000) and 9 horses ($1260), $2,260, at 6 per cent. per annum, .	0 37
Total, ...	$8 53

In comparison with the above, the following statement of the cost of running a steam car is submitted. The figures in this case are taken from actual experience with the Baldwin steam car and motors on the Market Street line, in this city, as well as on other lines where these machines have been used. It is proper to state that the allowance for repairs and maintenance of the car and machinery is estimated. There has been no expenditure on the steam car on Market Street in over five weeks' service, under this head. Such slight repairs as have been necessary, in the way of keeping the machinery in adjustment, have been attended to by the engineers. Two engineers per day are employed, giving them ample time to attend to this matter:

Cost of Running one Steam Car one Day.

Fuel, 88 miles, at 8 pounds per mile, equal to 704 pounds, at $4 per 2240 pounds, . .	$1 26
Oil, waste and tallow, ...	0 25
Wages of engineers, 16 hours, at 25 cts. per hour,	4 00
Repairs and maintenance of car and machinery, .	1 00
Daily interest on cost of steam car, $3000, at 6 per cent. per annum, ...	0 49
Total, ...	$7 00

Saving—steam over horse car, at $1.53 per day, equal to $558.45 per car per annum.

These figures, however, present only a partial view of the saving which may be effected. There are two elements of cost which are not

taken into account, viz.: the capacity of steam cars for greater speed, enabling a smaller number of cars to do the same service, and the saving in real estate and buildings requisite for stables, storage of feed, etc. In respect to the greater speed of steam cars, it should be remarked that this can be effected without increasing the rate of speed in the crowded streets of a city. Some saving of time can be effected even here, however, by the ability of the steam car to stop and start more quickly than a horse car; but a very great saving of time can be effected on the suburban parts of the line, by the possibility and desirability of a much higher speed than horse cars can attain. The following comparison is based on a road assumed to be worked by 50 cars and 450 horses. It will not be doubted but that the allowance of 40 steam cars to do the same service will be considered ample. It will also be admitted that one-fourth of the space will be sufficient to house the 40 steam cars, which would be required to house and stable 50 horse cars and 450 horses:

Annual Expenses of a Road worked by 50 *Cars and* 450 *Horses.*

Annual operating expenses, as above, .	$155,672 50
Interest on cost of real estate and buildings for car houses and stables (say $150,000), at 6 per cent., ...	9,000 00
Taxes, insurance on buildings and repairs of buildings, ...	3,000 00
Total, ...	$167,672 50

The same work could be done by 40 steam cars, at the following cost:

Annual operating expenses of 40 steam cars, as above, ...	$102,200 00
As stables may be dispensed with, and fewer cars require shelter, one-fourth the land and buildings would suffice. Interest on $37,500, cost of real estate and shed for steam cars, at 6 per cent., . .	2,250 00
Taxes, insurance on buildings and repairs of buildings, ...	750 00
Total, ...	$105,200 00

Annual saving, steam over horse cars, $62,472.50.

When these elements in the problem are taken into consideration, the saving which can be effected by a road worked as above, becomes enormous. In the above example it amounts to over thirty-seven and one quarter per cent. of the annual expenses for operating, taxes, insurances and repairs. It is believed that a much smaller proportion of steam cars, as compared with horse cars, than is assumed in above calculation, would suffice. On this point actual experience is requisite. It is certain, however, that the greatest economy and the most thorough solution of the problem will be reached by any company which abandons the old and commits itself fully to the new method of transit.

In this connection the following extract from the *Railroad Gazette* of September 22d, 1876, is given, having reference to the general principles connected with the use of steam for street railways, and especially to the separate motor above described:

"The problem of working steam on street roads has thus far been almost entirely in the hands of persons inexperienced in the construction of locomotive engines. It has been a very inviting field for immature engineers and scheming inventors, and they have pertinaciously clung to the idea of combining steam power with the vehicle for carrying passengers. This is open to a number of very grave objections. In the first place, the heat and the steam and smell from the boiler and machinery, being so very near to the passengers, is a very great annoyance; and secondly, if the engine gets out of order and must be laid up for repairs, the car must be laid up, too, and if the car gets out of order the engine must be laid up. The combination of the engine with the car also takes away much of the simplicity which may exist if the engine and car consist of two separate vehicles or units which can be coupled together or detached at will. An engine is also much more efficient if it can be employed to draw any car, and *vice versa* a car will perform more service if it can be coupled to any engine than if the two are inseparable.

"For these reasons many of those who have examined this subject carefully, and from a practical point of view, have concluded that the best kind of engine for street railroad service is the simplest possible form of locomotive, constructed so as to be entirely independent of the vehicle which carries the passengers.

"Quite recently we published an engraving of a French locomotive for street cars. This, it will be remembered, is a simple four-wheeled engine, inclosed by a very neat cab and coupled to an ordinary car.

"Since what may be called the Centennial discussion of the subject, the managers of the Baldwin Locomotive Works have given fresh

attention to the subject, and they have come to the conclusion stated above, that an engine independent of the car is very much better for this or any service, and they therefore designed and have just completed a locomotive for one of the Philadelphia roads in some respects similar to the French engine.

"These engines are, we believe, more promising of success than any other attempt in this direction has thus far been. They are in the hands of people who have some accurate knowledge of the effect of the law of gravitation on the operation of locomotives, and who can do more than guess at the steam-generating capacity of a boiler and of the proportions which one part of the machine should bear to another—information of which most of the schemers who have worked at this problem have been profoundly ignorant. Then, too, there is more hope of success if engines of this kind are built by good mechanics than if the workmanship on them is a sort of universal botch. We therefore expect to hear very soon of the successful use of steam power on street railroads, with a general expression of surprise on the part of everybody at the fact that it was never done before."

French Industrial Machinery.—The first steam engine was introduced into France in 1789. It was made by Boulton and Watt, of Birmingham, for the water-works of Paris. On account of the Revolution, and the consequent check of industrial enterprise, the manufacture of steam engines by French workmen did not assume much importance until 1824. The number of stationary engines had increased, in 1852, to 6000, representing 75,000 registered horse power; in 1863, to 22,500, representing 618,000 registered horse power; and now they represent 1,500,000 registered or 4,500,000 actual horse power, doing the work of 31,000,000 men, or of nearly ten times the available mechanical industrial population of the country.

In 1788, the cost of manual labor, in manufactured products, was 60 per cent , the raw material costing 40 per cent. Now, these proportions are reversed, the annual production being about 12,000,000,000 francs. Of this amount, 7,000,000,000 francs are paid for raw material, and 5,000,000,000 for labor. For the same amount of labor in 1788, an expenditure of 11,000,000,000 francs would have been required. There is therefore an annual saving of 6,000,000,000 francs, in consequence of the use of steam engines and improvements in machinery.—*Les Mondes* loc. cit.; from the *Journal Officiel.* C.

CERTAIN POINTS IN THE DEVELOPMENT AND PRACTICE OF MODERN AMERICAN LOCOMOTIVE ENGINEERING.

By FRANCIS E. GALLOUPE, S. B.

[Continued from Vol. ciii, page 315.]

The resistance of the atmosphere also varies as the square of the speed. The train displaces a volume of air somewhat wider than the cars, which it carries along with it, and which causes an additional resistance by its friction against the surface of the ground.

The following are the directions and velocities of the wind during the three days on which data were taken, which I have obtained from the U. S. weather signal office in Boston.

Record of Wind.—Wednesday, March 15: general direction, W.; velocity, at 11·30 A. M., 36, at 12·35 P. M., 48 miles per hour.

Thursday, March 16: direction, veered to E., at 9·40 A. M.; velocity at 11 A. M., at Boston, 20 miles per hour. Thursday night at midnight, 30 miles per hour.

Friday, March 17: direction, wind continued E. till Friday noon; velocity, at 11 A. M., the maximum, 24 miles per hour, when the direction changed to N. E., and at 12·43 P. M., to N. W.

The formula employed by the U. S. signal service, by which to calculate the pressure of the wind from its velocity, is one used by Col. Henry James, R. E. F. R. S., and derived from a *Meteorological Paper of the British Board of Trade*,[1] in which the pressure per square foot, $P = v^2 \times \cdot 005$.

On this day the wind was almost dead against the train, and if we take its velocity at 36 miles per hour, the resistance due to this cause, calculated by this formula, was 6·48 lbs. per sq. ft., while that due to the velocity of the train itself, which was 30 miles, was 4·5 lbs. If we take the front exposed to this pressure at 13 feet in height and 9 in width we should have for the total atmospheric resistance, $10 \cdot 98 \times 117$ sq. ft. = 1285 lbs.

[1] Third No., page 99. See also a table calculated by same formula in Alex. Buchans' "Handy Book of Meteorology," and Loomis' "Meteorology."

The resistance of the atmosphere, wind, and of curves under one mile radius, are usually taken together and allowed for in the formula. Mr. Zerah Colburn, in "Locomotive Engineering," estimates that these increase the resistance one-half, or 50 per cent. Applying this correction to our resistance of 2296 lbs. previously found, we find for the total resistance, constantly overcome by this engine, reduced to the rail, 3444 lbs. If we add instead, our calculated atmospheric resistance, we get $2296 + 1285 = 3581$ lbs., which agrees pretty well with the above rule. But we have calculated that the tractive force, here, was 5671 lbs., and if we take the velocity of the wind at 48 miles per hour, instead of 36, we have the corresponding resistance, 1872 lbs., and the total resistance 4168 lbs., leaving 1503 lbs. unbalanced force for other resistances which must have existed as we have seen before, if the train was at a uniform velocity. This can be easily explained, for if the wind was ever so little upon one side of the train, a greatly increased area would be presented, upon which it would act.

The Efficiency of the Engine or Mechanism can now be found. The efficiency of the engine or mechanism

$$= \frac{\text{Useful work}}{\text{Useful work} + \text{the lost work}},$$ or, it is the ratio of the useful resistance overcome, to the total energy of the fluid on the piston. It is the product of the efficiencies of the pieces which transmit the power, and if the discussion of these parts of the engine had been taken up, it might be so found, by reducing the resistance overcome by each, to the driving point, or piston, by means of the principle of virtual velocities.

The formula for the efficiency of the mechanism as a whole, was originally proposed by the Count de Pambour, and is given by Rankine as follows:—

$$e = \frac{R_1 \text{ (Useful load)}}{R \text{ (Total resistance reduced to piston)}}$$

$$= \frac{R_1}{(1 + f)\, R_1 + R_0} = \frac{1}{1 + f + \frac{R_0}{R_1}}.$$ The total resistance R, consists of a constant part, R_0, which is the resistance unloaded, and a part increasing as the useful load. R_1. Now, the unloaded resistance, R_0, in the best engines, is, on an average, 1 lb. per square inch of piston,

or $R_0 = 1$ lb. $\times A \times 2 = 1 \times 201$ sq. in. $\times 2 = 402$ lbs. upon the two pistons. The value of the coefficient, f, the Count de Pambour takes at $\frac{1}{7} = \cdot 143$. Now, if we take the resistance overcome in moving the train at 30 miles an hour, as the useful load, or

$R_1 = T = \frac{4\, p\, A\, S}{\pi\, D} = 3444$ lbs. and reduce it to the piston, we obtain $2\, p\, A = \frac{R_1 \times \pi\, D}{2\, S} = \frac{3444 \times 16\,36}{4} = 11{,}585{\cdot}9$ lbs., and $\frac{R_0}{R_1} = \frac{2\, A}{2\, p\, A} = \frac{402}{11{,}585{\cdot}9} = \cdot 0347$. The efficiency of the mechanism is accordingly, $\frac{R_1}{R} = \frac{1}{1{\cdot}143 + \cdot 0347} = \cdot 85$ or 85[1] per cent. But this appears to be too high. From the speed and pressure given, the tractive power of 5671 lbs. which we found, must have balanced the resistances, and not have exceeded them, as the condition of uniform speed. Hence, if we take the resistance at 5671 lbs., at the circumference of the driving wheels, in the same manner as above, we find the effective pressure upon the pistons to be 23,194 lbs., the effective energy exerted per revolution, 92,778 ft. lbs., and the efficiency, 80 per cent.

But we may calculate it by yet another method. The tractive power exerted was 5671 lbs., the power consumed in overcoming the machinery friction, reduced to the rail, we have found to be 714 lbs. The efficiency of the mechanism is therefore, $\frac{5671 - 714}{5671}$, which gives 87 per cent.

In completing what I have had to say upon certain points in locomotive engineering, I have endeavored to present, not a finished essay upon the subject, but, perhaps, the less interesting results only, of the study and time devoted to it. Nothing has been said upon those important branches of locomotive engineering,—the permanent way, railway plant, watering stations, and shops, surveys and location of road, bed and ballasting, masonry, tunneling, the superstructure, rolling stock, or railway management. Nor upon the construction of locomotives in the workshop, and their draughting. Taking simply a single example of the finished product of our New England loco-

[1] From experiments by Mr. Wm More and others, as stated by Rankine, the friction of the pistons alone was estimated at one-tenth the effective pressure, or 10 per cent.—"Mach. and Millwork," pp. 399 and 405.

motive establishments, I desired to apply to it some of the principles which we have been studying during our four years' course.

What I have been able to take up seems to me only suggestive. The subject is capable of indefinite development; it is inexhaustible.

To review, we have found the efficiency of the apparatus by which a portion of the energy in the coal is transferred to the working fluid; next the efficiency of this fluid has been ascertained; and finally, the efficiency of the mechanism, by which a portion of the energy utilized in the latter, has been finally given out as useful work, at the circumference of the wheels. The absolute efficiency of the locomotive is therefore the product of the three factors found, and is as follows:

1. Efficiency of Furnace and Boiler, . . ·557.
2. Efficiency of Steam, ... ·071.
3. Efficiency of the Engine or Mechanism, . ·800.

Efficiency of the Locomotive engine, $\cdot557 \times \cdot071 \times \cdot8 = \cdot0316$, or *three and two-tenths per cent.* Of the power in the coal, *ninety-six and eight-tenths per cent.* is lost. Of the 10,316,236 foot pounds of work in each pound of coal, but 339,120 are utilized. For every ton of coal, costing \$6.00 per ton, $19\frac{2}{10}$ cents are usefully invested, and \$5.80$\frac{8}{10}$, ineffectually applied. Of this, however, the greater portion, perhaps nearly 70 per cent.,[1] is lost by reason of natural conditions beyond our control.

The projects by which the locomotive engine is to be improved, by this remaining 20 or 30 per cent., relate to nearly all its parts. The boiler is an extremely wasteful piece of apparatus; its efficiency will be increased as the difference between the limits of temperature employed for the working fluid is greater, and hence when high pressures can be used, such as 200 or 400 lbs. to the square inch, and which depends in turn upon the introduction of seamless steel or welded boilers, or when means for condensation or for utilizing pressure below that of the atmosphere shall be rendered practicable, and when fuel shall have become more expensive, doubtless, eventually, other means will be employed for the production of power.

The defect in the use of steam seems to be radical. But a small proportion of the heat absorbed by it can be utilized. Although its use may sometime be abandoned, and the theoretic superiority of air,

[1] Art. "Losses of Power in the Steam Engine," *Scientific American*, Jan. 11, 1873.

as the absorbing and transmitting fluid can be easily shown,[1] and engines for its use have already been constructed, their complexity, and the other difficulties that stand in the way of their construction have as yet prevented them from exhibiting any superiority to the steam engine in its usual form.

In the mechanism it seems as if the limit of improvement had nearly been reached. The beauty and simplicity of the Stevenson link motion, the crank and its connections, leave nothing to be desired. The various forms of rotary engines have all disappeared before it. It is not to be doubted, however, that the action of the ordinary slide valves is imperfect, and here improvements, such as the "central exhaust," are from time to time being made.

The advantages or disadvantages of using superheated steam, or jacketing the cylinder with live steam, have been briefly considered in the part on steam.

Outside of these questions lies that of gauge. It has been affirmed that the expense of locomotive power and permanent way has been found to vary nearly as the gauge. In regard to this much disputed question, it has been my intention to work out further data, similar to those which have been given, for comparison, from one of the most successful of the narrow gauge roads—the Boston, Revere Beach and Lynn Railroad.

There can be good reasons given for altering nearly every detail for improvement in the locomotive engine, in directly opposite ways, and the excess of advantage of one over the other will determine in which direction the improvement shall lie.

To quote again from Professor Thurston, on this topic: "The direction of improvement has been marked by a continual increase of steam pressure, greater expansion, provision for obtaining dry steam, high piston speed," and "careful protection against loss of heat by conduction or radiation." To store the energy wasted by the brake, and to dispense with the present necessity of dragging a heavy tender weighing nineteen or twenty tons, would be steps in improvement relating to the locomotive as a whole. It would be to more effectually apply whatever power is already obtained in its final form.

There seems to be little inducement to perfect and economize in the operation of the locomotive at the present time, on account of

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[1] Bourne's Treatise.

the indifference of those most concerned in regard to its practical efficiency. The value of making locomotive tests has, until now, been apparently little appreciated. Where the supply of motive power is unlimited, there is no practical value in a test whereby the possibility of a reduction in the amount of power required to do the same work may be indicated. If there was at Lowell more water power than could be possibly used, it is not likely that such care would have been bestowed and expense incurred, by the mill corporations, in accurately testing the water power and turbines there employed.

But with the locomotive engine, coal is not only a large item in the expense of railroads, but it also occupies space and consumes power in its transportation, and involves the expense of labor in applying it to its use. On railroads every shovelful, after it is landed in the coal sheds, is usually handled over from two to four times. Hence arises the practical value of tests by which the actual economy or wastefulness of the engine is indicated, and the direction in which to look for further economy and reduction in the necessary amount of coal pointed out.

Let us for a moment consider what should constitute such a test. A kind of test that has been at times employed for locomotives, has been to ascertain the number of cars, of known weight, that a given locomotive will haul up a certain grade or around a given curve, the speed being ascertained by noting the time occupied by the train in going a certain distance. But this really tells only the gross power of the engine, and does not inform us at all of how this power is distributed in the engine, what parts are efficiently working, and what not. A real test would be one carried on while the engine is doing its regular work, such as, for instance, carrying a train of a certain weight from Boston to Portsmouth and return. Let all the instruments of precision used for making tests—weighing scales, measuring scales, for the coal and water; a standard clock or watch for the time, a bell to indicate the time for the simultaneous taking of observations, the barometer, thermometers and pyrometers for the indication of temperature in the boiler, steam dome, steam pipes, steam chest, cylinders, tank, furnace and smoke box, the elegant recording steam gauge for the pressure, the friction brake, the dynamometer, the speed recorder or the counter, and the indicator—be employed, that are practicable in the limited space available by the construction of the locomotive. Let posts of observation for the

reading of these instruments be established at the points indicated—at the cylinders, in the cab, tender, and on the train—and complete logs kept of all the circumstances relating to the engine, without regard to their apparent irrelevancy to the subject, for it is owing to insufficient data that many records now obtained are rendered nearly valueless. And, finally, let the refined methods of physical science be applied to the data for the corrections; analyses made for the combustible matter in the coal, and especially the amount of moisture, the instruments re-tested, their errors ascertained and corrections applied.

From the data obtained at such a test, the details of which I might elaborate to a much greater extent, but the nature of which is sufficiently indicated in the outline above, when worked out and compared, we should obtain such a knowledge of the deficiencies in the locomotive as to show at once in what direction to look for further improvement and economy. It would place locomotive engineering upon a level with that of the other branches of mechanical engineering, and be of general scientific service besides. For it is only the exact facts that scientists and theorists require, in order to obtain a new insight into the working of the physical laws by which all our machines are governed, and produce results to which practice alone would never attain.

I cannot conclude with a more important observation than that of the real need of strict, accurate scientific tests. When such tests are made upon locomotives as that made in Jan., 1876, upon the pumping engine for the Providence Water Works, locomotive practice will not remain stationary, and locomotive engineering science will progress, ensuring results of practical benefit to all.

Cutting Cast Iron Tubes of Large Calibre.—An apparatus for this purpose, invented by Reishauer and Bluntschli, of Zurich, is described in the *Schweizerisches Gewerbeblatt* for 1876, p. 130. It is constructed of three cutting wheels, resting in stirrups which are pressed upon the tube by a connecting vice-screw. A cutting iron, between two of the cutting wheels, is pressed against the tube by a second screw, and the whole apparatus is turned around the tube by hand.—*Ding. Polyt. Jour.*, 223, 4. C.

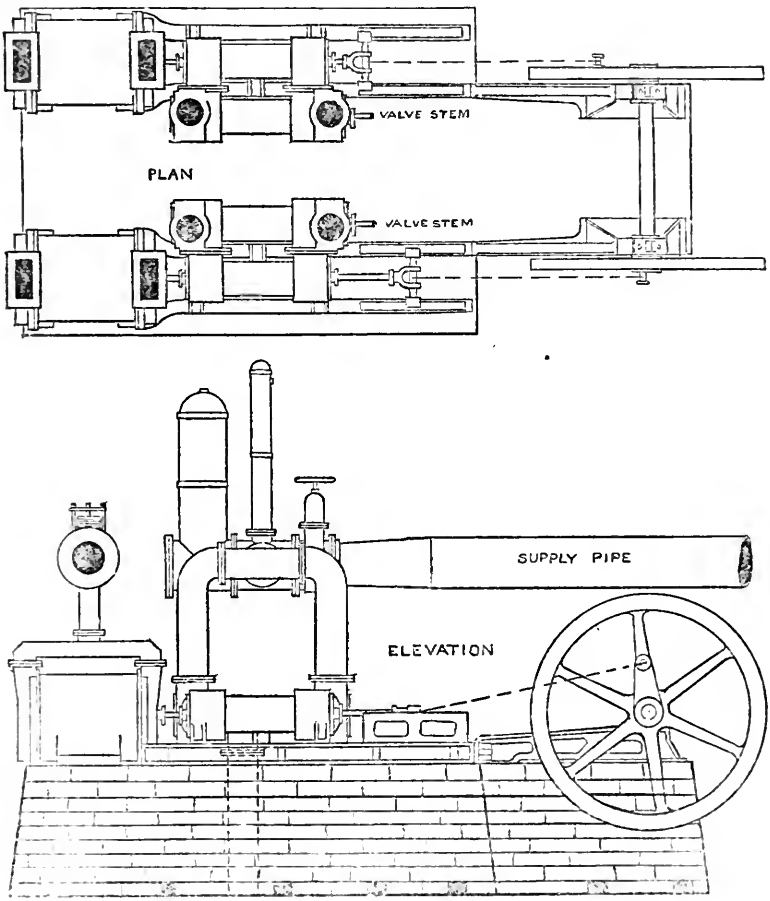
ROTATIVE WATER-PRESSURE ENGINE.

By Washington Jones, M.E.

The I. P. Morris Company, of this city, have constructed recently, at their Port Richmond Iron Works, a pair of water-pressure rotative engines, from the designs of Messrs. Taws and Hartman, mechanical engineers, and under the supervision of Mr. William Firmstone, President of the Longdale Iron Company, of Virginia ; and intended to supply blast for that company's coke furnace at that place. As this is the only engine of the kind used in the United States, or elsewhere, so far as the writer is aware, to produce blast for a furnace, a description may be of interest. The general plan of the engine is not novel, being that in which the two cylinders for air and, in this case, water are in line, and, with a piston-rod common to both, secured at front end into a cross-head moving on guides, and carrying a connecting-rod whose outer end takes hold of a crank-pin fitted into hub of fly-wheel. The engines are coupled by one shaft, with cranks at right angles, and are mounted upon strong bed-girders, which extend from blast cylinder flange, under the water cylinder and beyond, so as to contain the shaft pedestals. The usual guides for cross-heads are bolted on top of these girders, and the whole is securely held down to a masonry foundation. The cylinders have the diameters of 18 ins. for water, and 48 ins. for blast, both of 5 ft. stroke. The pistons are fitted with double metallic rings, set out with springs. The water admission and discharge valves are of the piston type, 18 ins. diameter, and are also fitted with adjustable spring packing. Motion is given to them by the ordinary eccentrics and rods. The water is taken from a dam 65 ft. above the centre of water cylinders, and the available supply in dry seasons amounts to 4 cubic ft., but, ordinarily, to 6 cubic ft. per second. Sufficient of this quantity is conveyed by a riveted lap-jointed plate iron flume of 30 ins. diameter, and which is laid to conform with the general contour of the bank. From its point of attachment, to a wooden trunk of 5 ft. depth by 10 ft. width, it dips, at an angle of 20°, for 70 ft.; thence, by an easy bend, at an angle of 38° 30′, for 53 ft.; then changing, by another easy bend, into a horizontal line, it continues for 34 ft., when its diameter diminishes, in a length of 6 ft., to 24

ins., at which size it runs for 4 ft., and then branches right and left to the side pipes of water cylinders. The main pipe extends on for a short distance, and is then closed by joining an air vessel which is

WATER-PRESSURE ROTATIVE BLAST ENGINE OF THE LONGDALE IRON CO.

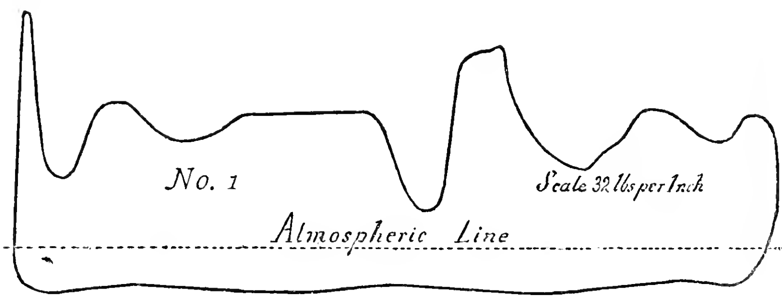


24 ins. diameter and 9 ft. high. Each of the branches is supplied with an air vessel of 10 ins. diameter and 9 ft. high. The exhaust water is discharged immediately downwards through a pipe $14\frac{1}{2}$ ft. long, having its lower end, below the surface, in waste water way, which is 13 ft. below the centre of water cylinders.

The engines made, when first put up, $8\frac{1}{2}$ double strokes per minute, but have been run up to 12 double strokes, without noise or shock. The blast pressure, when blowing into the furnace, was $3\frac{1}{2}$ pounds; sometimes it fell as low as 3 pounds, but only at such times when the throttle-valve in water supply pipe was not fully open. Their steadiness of motion may be attributed to the large areas of water valves and chambers, they being equivalent to that of the water cylinders, and the freedom from shocks is due to the position and ample size of the air vessels, their aggregate capacity being over twice that of the water cylinders, or as 38 to $17\frac{1}{2}$, and also to the large area of the flume pipe, which conveys a sufficiency of water at a low velocity, or

$$\frac{1{\cdot}767 \times 5 \times 2 \times 2 \times 8\frac{1}{2}}{4{\cdot}908 \times 60} = 1{\cdot}02 \text{ ft. per second.}$$

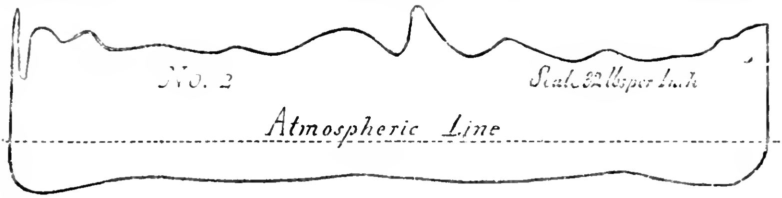
All the air carried into the cylinders by the water is permitted to escape by means of a bent pipe attached to the highest part of valve casings, and carried downwards into a vessel of water.



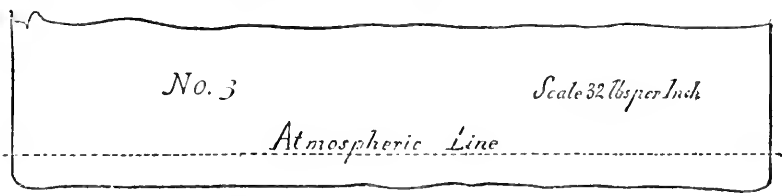
The furnace supplied with blast by these engines has a diameter at boshes of 11 ft. and a height of 60 ft., with a closed top, and yields 130 to 150 tons of hot blast coke pig per week.

The accompanying indicator diagrams, taken from water cylinder, show the effect produced by the use of air vessels on the water supply pipe, and of air escape pipes on valve casings. No. 1 was taken from forward end of water cylinder of engine No. 1, at a time when air vessels and air escape pipes were not in action. The number of revolutions were not noted, but they were evidently less than usual as the blast pressure was but 3 pounds per square inch. This was intended as a test to determine the efficiency of the air vessels. At the middle point of the admission line the sudden depression is evidently produced by the opening of valve on engine No. 2 to admit

water to its cylinder just when the piston of No. 1 had attained its greatest velocity, and the greatest supply was demanded; and, following it, an abrupt rise above the mean line due to the impulse of the accelerated motion and the sudden check of water column in supply pipes. This effect is twice repeated before the termination of the stroke, but in lessening degrees, and is caused, as stated, by the oscillations of the water column, and the presence of trapped air in valve casings. The action of engines was not even, and strong shocks



were produced: they were therefore stopped, and the two air vessels upon the valve chests put into use, but air escape pipes and cocks remained closed, and engines again started, with a result as seen in card No. 2, where the unevenness of the admission line is very much softened but still unsatisfactory. The revolutions were $7\frac{1}{2}$ per minute, blast pressure $2\frac{3}{4}$ pounds. All the air vessels were then put into use, air escape cocks opened, and card No. 3 taken, which is quite satisfactory. The engines then had been running four hours, making $8\frac{1}{2}$ revolutions kindly, and producing a blast pressure of $3\frac{1}{2}$ pounds



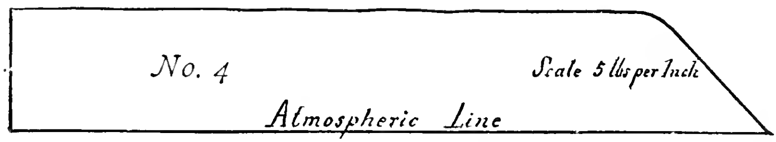
per square inch. As circumstances required the location of engines to be at their present level of 13 ft. above surface of water in waste way, which diminished the head to that extent, the continuation of the exhaust water pipe below the water, utilizes the negative pressure due to the difference in levels. This will be seen on card No. 3, where the exhaust line falls below the atmospheric line 5·625 pounds.

The gross power of the water expended during one double stroke of the engines, assuming the capacity of the cylinders as the basis for determining its quantity, is equal to

$1{\cdot}767 \times 5 \times 2 \times 2 \times 78 \times 62{\cdot}4 = 172{,}007$ ft. pounds. When

running with the throttle wide open the blast pressure obtained was 4 pounds, corresponding to a power developed of $1809 \cdot 56 \times 5 \times 2 \times 2 \times 4 = 144{,}765$ ft. pounds. Consequently, the useful effect of machine is equal to $\frac{144765}{172007} = 84$ per centum.

As 4 pounds of blast are more than is required for the furnace, and as the supply of water is somewhat less than anticipated, the water cylinders were reduced recently by bushings to a diameter of $15\frac{3}{4}$ inches. The engines now run regularly at 12 revolutions per minute, and give a blast pressure of $2\frac{7}{8}$ pounds. The power developed is equal to $1 \cdot 353 \times 5 \times 2 \times 2 \times 78 \times 62 \cdot 4 = 131{,}702$ ft. pounds, and the work done in the blast cylinders is equal to $1809 \cdot 56 \times 5 \times 2 \times 2 \times 2\frac{7}{8} = 104{,}050$ ft. pounds. Consequently



the useful effect of the engines is now $= \frac{104050}{131702} = 79$ per centum.

The increased loss of effect, $84 - 79 = 5$ per centum, results from the reduction of capacity of water cylinders or a lessened power, whilst the prejudicial effect of friction of machines, of the water through the flume and the passages, and of the several right-angled bends given to the current before it acts upon the piston, remains practically the same as before the reduction.

Card No. 4 was taken from blast cylinder at the same time No. 3 was taken from water cylinder, and is given here only to show that blast cylinder valves are of ample proportions; and that no undue loss occurs in getting the air into or out of blast cylinders.

Before the adoption of this type of motor was decided on, it was considered by the proprietors, whether to build an overshot wheel, or to put in a turbine, or the proposed plan of the yet untried water pressure rotative engine. Objections existed against the use of the first two, as gearing had to be used to transmit the power to the work. It was therefore determined to try the engines just described, and their performance is so superior to any probable result from an overshot wheel or a turbine as to satisfy those concerned of the soundness of judgment evinced in their adoption.

ON THE PRODUCTION AND USE OF COMPRESSED AIR IN MINING OPERATIONS.[1]

By M. F. L. Cornet, Chief Engineer of the Mines of Eastern Flenu à Cuesmes, Cor. Member of the Scientific Section of the Royal Academy of Belgium.

[Translated from the French by Robert Zahner, Department of Engineering, Stevens Institute of Technology.] [II]

Compressed Air.

§ 1. Of all means employed to drive the machinery of mines, compressed air is certainly that which is least objectionable, both on the scores of safety and convenience; but its application necessitates considerable expense in its first establishment, and the work which it yields, with the machines used at the present day, is only a small fraction of that which is expended in obtaining it at the surface.

[1] Considérations sur la Production et l'Emploi de l'Air Comprimé dans les travaux d'exploitation des mines, par M. F. L. Cornet, Ingénieur-Directeur des travaux des charbonnages du Levant du Flenu à Cuesmes, correspondant de la classe des Sciences de l'Académie Royale de Belgique. Deuxième édition. Mons, Hector Manceaux, imprimeur-éditeur. 1876.

[II] Note.—The writer, some months ago, while studying the causes of loss of work in the use of compressed air—more particularly in its application to the actuation of rock drills and other mining machinery—was led to propose the more effective utilization of water in the absorption of the heat of compression, by injecting it in the condition of a very fine spray, as by the use of an atomizer, and under some peculiar conditions, in other respects, which need not be described here; and he soon after requested his colleague, Prof. De Volson Wood, to endeavor, by its experimental application, to determine whether the increased efficiency which seemed to be promised could be actually utilized. Meantime, the brochure of M. Cornet, of Mons, was received, and, finding it to contain a brief discussion of a plan resembling his own, so far as it went, the writer requested Mr. Zahner to translate it. It is here presented, as read before the classes of the Department of Engineering of the Stevens Institute of Technology, in the expectation that it may also interest some of the readers of the Journal.—R. H. Thurston.

Table of Factors.

1 metre = 39·37 inches = 3·28 feet.
1 kilogramme = 2·205 pounds.
1 kilogrammetre = 7·23 foot pounds.
1 cubic metre = 35·32 cubic feet.
1 litre = 0·220 gallons.

1 "cheval à vapeur," or "force de cheval," = 75 kilogrammetres per sec. = 0·986 horse-power.
1 degree Cent. = $\frac{9}{5}$ degree. Fahr.
1 calorie = 3·968 Brit. thermal units.

Nevertheless, air, like all permanent gases, has perfect elasticity, and, to be compressed to any tension, requires, theoretically, only a quantity of work strictly equal to that which it restores when returned to atmospheric pressure. Thus would it be in practice, allowance having been made for the losses attendant upon the use of all machines, if the compressed air were used immediately after leaving the compressor. But if, as is the case wherever this motor is employed, the air is relieved only after having been compressed for a considerable time, and in a machine situated at a great distance from the compressor, there occurs a physical change, which carries away a great part of the mechanical power which has been transmitted to it; if, during compression, the temperature of the air were to remain equal to that of the atmosphere from which it is drawn, the tension would increase according to Mariotte's law; that is to say, its pressure would, at every point in the course of the compressor-piston, be inversely proportional to the volume. But the work transmitted to the air is partly converted into heat, and the temperature increases with the tension. It follows from this that the tension increases more rapidly than is indicated by the law of Mariotte, and, consequently, the work necessary for compression is greater than it would be were the temperature of the air to remain constant.

COMPRESSION OF AIR.

Tension in Atmospheres.	Compression with Temperature const.		Compression with increase of Temperature.			Excess of the work due to heating the air.	Ratio between the quantities of the two preceding columns.
	Volume.	Work.	Temp.	Volume.	Work.		
Atm.	Cubic metre.	Kgm.	Degrees. C.	Cubic metre.	Kgm.		
1	1·000		20°	1·000			
2	0·500	7130	85·5°	0·612	7932	733	0·092
3	0·333	11356	130·4°	0·459	13360	2004	0·150
4	0·250	14269	165·6°	0·374	17737	3477	0·196
5	0·200	16580	195·3°	0·320	21209	4629	0·213
6	0·167	18475	220·5°	0 281	24310	5835	0·240
7	0·143	20038	243 2°	0.252	27048	7040	0·260
8	0 125	21422	263·6°	0·229	29518	8096	0·274

In order to give a complete exposition of the calorific effects which compression exercises upon air, we have prepared a table in which we furnish the results obtained by a calculation based on the

hypothesis that a cubic metre of air, taken at atmospheric pressure and at a temperature of 20° C., is given tensions of from one to eight atmospheres.[1]

We see, on examining this table, that with the compression following Mariotte's law, the volume of one cubic metre of atmospheric air is reduced to 0·125 cubic metre, when the tension reaches eight atmospheres; while if the compression is accompanied by an increase of temperature, and occurs without any loss of heat, the volume for the same tension measures 0·229 cubic metre. In raising the tension of the air from one to eight atmospheres, the temperature rises from 20° to 263·6° C., which produces this increase of volume after compression. In fact, for each elevation of 1° C., air possesses the property of expanding by a quantity equal to 0·00367 of the volume which it would occupy at the temperature of melting ice. We shall suppose now that, in escaping from the compressor, the air is introduced into a reservoir of very great capacity, where it remains sufficiently long for its temperature to become equal to that of the surrounding air; that is to say, equal to 20° C. If we then cause it to enter the cylinder of an expansion-engine, the phenomenon appears, to which we are about to refer.

Work at full pressure will be done without any sensible reduction of temperature, for the cylinder will remain, while doing this work, in communication with the reservoir, whose capacity we have assumed to be very great. But, beginning at the instant of cut-off, the work done by expansion will be at the expense of the heat which the air contains. The temperature will fall the more, the further expansion is carried, so that the decrease of tension in the cylinder will proceed in a much more rapid progression than that which the law of Mariotte gives. The quantity of work which the air yields will, therefore, be less than that which would have been obtained if the expansion could have proceeded according to this law.

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[1] The temperatures and volumes were calculated by means of the formulæ, $\frac{T}{T'} = \frac{P}{P'} \times \frac{291}{1000}$, and $V' = V \frac{P' \, T}{P \, T'}$, in which T' is the absolute initial temperature (*i. e.*, $273 + 20 = 293°$; $T =$ the absolute final temperature); P' the initial tension, or one atmosphere; P the tension to which the air is brought; V' the volume occupied by the air after compression; and V the volume before compression. In the case chosen $V =$ one cubic metre. The quantities of work were determined by the aid of a polar planimeter on the diagrams which are annexed to this paper.

In the following table we compare the results which the law of Mariotte would furnish with those which could be obtained if two cubic metres of air, taken at atmospheric pressure, were caused to expand, having been given the tensions of five and eight atmospheres respectively, and restored, by cooling, to the temperature of 20° C.:

EXPANSION OF AIR.

INITIAL TENSION OF EIGHT ATMOSPHERES.					INITIAL TENSION OF FIVE ATMOSPHERES.				
	Mariotte's Law.		Exp'n with Cooling.			Mariotte's Law.		Exp'n with Cooling.	
Tensions in Atmospheres.	Temperature.	Volumes, cu. metres.	Temperature.	Volumes, cu. metres.	Tension in Atmospheres.	Temperature.	Volumes, cu. metres.	Temperature.	Volumes, cu. metres.
8	20°	0·125	+ 20·00	0·125					
7	20°	0·143	+ 8·80	0·137					
6	20°	0·167	— 3·50	0·153					
5	20°	0·200	— 17·40	0·174	5	20°	0·200	+ ·20°	0·200
4	20°	0·250	— 33·50	0·204	4	20°	0·250	+ 1·60°	0·234
3	20°	0·333	— 52·70	0·251	3	20°	0·333	— 20·40°	0·287
2	20°	0·500	— 77·20	0·334	2	20°	0·500	— 48·70°	0·383
1	20°	1·000	— 113·00	0·546	1	20°	1·000	— 89·50°	0·626
0·426	20°		— 148·20	1·000	0·526			— 120·80°	1·000

If expansion proceeds according to Mariotte's law, the tension will always be exactly restored to atmospheric pressure, when the volume of the air becomes equal to one cubic metre; *i. e.*, at the instant the piston has completed its course. But it is far from being so in the case in which the air undergoes considerable cooling while expanding. We see, on examining the table, that in the cylinder where the air was made to expand from a tension of eight atmospheres, atmospheric pressure is reached when the volume is only 0·546 cubic metre; that is, when the piston has traveled 0·546 cubic metre, its stroke being 1 metre, from this point the tension becomes less than that of the atmosphere, and it has descended to 0·426 atmosphere, when the volume reaches 1 metre—that is, when the piston has completed its stroke.

We have seen above, that in order to give 1 cubic metre of air, taken at atmospheric pressure and 20° C., a tension of 8 atmospheres, it is necessary to consume 29,518 kilogrammetres of work, if we allow the temperature to increase.

When this compressed air is restored within the reservoir to a temperature of 20° C., and is then made to expand cooling, it yields

16,146 kilogrammetres of work. But a part of this work, equal to 1657 kilogrammetres, is consumed in overcoming atmospheric pressure, so that the work actually realized is only $16146 - 1657 = 14489$ kilogrammetres. The theoretically useful effect in this case is, therefore, only $\frac{14489}{29518} = 0{\cdot}490$.

If the tension of the air is 5 atmospheres, the consumption of work, in compression, amounts to 21,209 kilogrammetres. The work restored is 13,296 kilogrammetres; but 1085 kilogrammetres are spent in overcoming atmospheric pressure. Hence, 12,211 kilogrammetres remain free, and the useful effect amounts to $\frac{12211}{20209} = 0{\cdot}575$.

The loss of work is therefore less, with a tension of 5, than with one of 8 atmospheres. We may conclude that the useful effect decreases as the tension increases. This fact would be made more evident if calculations, similar to those whose results we have just given, were made for all tensions between 1 and 8 atmospheres.

The useful effects which we have just calculated for 8 and 5 atmospheres respectively, are theoretical, and could be obtained only with machines which would offer no passive resistance, no "dead spaces" (*espace nuisible*), and which could be put in communication with the compressor by pipes offering no resistance to the movement of the air. But we know that this is far from being the case in practice, and we think we ought to consider, as a minimum, a total loss equal to 30 per cent. of the motive power of which we dispose. Assuming this proportion we find, for the two cases we have chosen, that the useful work will be:

Tension eight atmospheres:— $\frac{14489 \times 70}{100} = 10{,}142\ \mathrm{k^m}$.

Useful effect: $\frac{10142}{29518} = 0{\cdot}343$.

Tension five atmospheres:— $\frac{12211 \times 70}{100} = 8548\ \mathrm{k^m}$.

Useful effect: $\frac{8548}{21209} = 0{\cdot}403$.

These useful effects are still greater than those obtained in practice, by reason of the occurrence, during expansion, of a phenomenon of which we have not yet spoken. Atmospheric air, even in the dryest seasons, always contains a certain quantity of water which maintains

itself in a state of vapor in the compressed air until expansion takes place in the cylinder. If the expansion be carried far enough, the temperature falls below the freezing point, and there is deposited in the ports of the cylinder a crust of ice which thickens rapidly and soon arrests the motion of the machine. This is why most of the compressed air machines produced up to date do not utilize expansion. Now, the quantity of work, which at full pressure any volume of compressed air can furnish, is very much below the sum total of the mechanical power which it possesses, as we may judge by the following figures, which represent the quantities of work which a cubic metre of atmospheric air, compressed to tensions of from two to eight atmospheres, can furnish by expansion and at full pressure:

Tensions. Atmos.	Work in Kilogrammetres.		Total Work.	Ratio between the Figures of Cols. 3 and 4.
	By Expansion.	At Full Pressure.		
1	2	3	4	
2	1963	5167	7130	0·725
3	4474	6882	11356	0·606
4	6510	7750	14260	0·543
5	8313	8267	16580	0·498
6	9867	8608	18475	0·466
7	11184	8854	20038	0·441
8	12380	9042	21422	0·422

We see by the above figures how important is the loss of work if air is used at full pressure only. The loss is greater as the tension is higher. Also, if we do not work expansively, the air must, for the sake of useful effect, be under the least possible tension.

We have calculated also above, the quantities of work which could be obtained from compressed air by carrying the expansion to its extreme limits. These, although very small relatively to the work consumed, are, nevertheless, larger than the work realized by employing air at full pressure only. We have, indeed, for the two cases chosen, the following results:—

Tension of eight atmospheres:—

Work consumed, ... 29,518 k^m.

" realized, $\frac{9042 \times 70}{100} =$. 6329 k^m.

Useful effect, $\frac{6329}{29518} =$ . . . 0·214.

Tension of five atmospheres:—

Work consumed, . . . 21,209 k^m.

" realized, $\frac{8267 \times 70}{100} =$. 5787 k^m.

Useful effect, $\frac{5787}{21209} =$ . . 0·273.

In conclusion of this part of our work, we shall say then, that, if we employ no means for preventing a rise of temperature in the air during compression, or a fall during expansion, we shall secure in useful work only a small fraction of the power consumed. For a tension of five atmospheres, or four atmospheres over and above atmospheric pressure, which is that pretty generally used, the work usefully restored exceeds but little, a quarter of that which has been expended in compressing the air.

§ 2. We shall now enter upon the second part of our work, in which we intend to treat of the methods to be employed in order to derive from the use of compressed air a greater useful effect than that secured at present. These methods consist in the following:—

(1) To bring about in the compressor the cooling which the air now undergoes after having left it.

(2) To provide the expanding air with a quantity of heat sufficient to keep its temperature constant, or at least to keep it from descending so low as to produce ice.

The compressors now in use belong to two principal classes. In the one, the compression is effected in the presence of water, while in the other it is done with the air in the dry state, water being applied only to the exterior of the machine to cool its walls.

Where cooling is the object, compressors of the first of the above classes seem to present greater advantages than those of the second, since the air is here in direct contact with the water; while in machines which compress the air dry, the air is separated from the water by thick cast-iron walls. Meanwhile, the results derived from experiment prove that, compressed in the presence of water, air undergoes but a slight cooling. Fig. 1 represents a diagram taken from the air compressor used in the Marie colliery at

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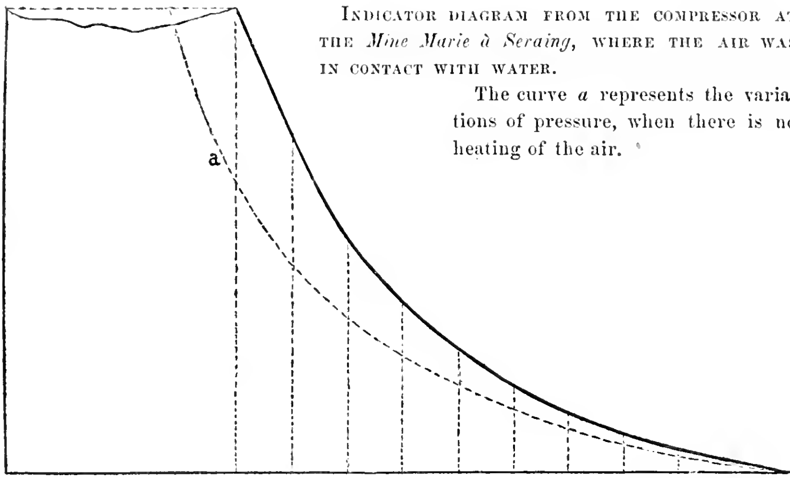
[1] *Compressed-Air Drilling Machines*, applied to mining operations, by M. A. Daxhelet. Annual of the Society of Engineers of L'École de Liége, Vol. XV.

Seraing[1]. The stroke of the compressor piston is 1·2 metres and its diameter is ·45 metre. The mean pressure per square metre, calculated from the diagram, was 19,962 kilogrammes, corresponding to 3809 kilogrammetres of work. The dotted curve in the diagram is the one which would have been traced had the compression followed Mariotte's law; that is, had the air not been heated during the com-

Fig. 1.



INDICATOR DIAGRAM FROM THE COMPRESSOR AT THE *Mine Marie à Seraing*, WHERE THE AIR WAS IN CONTACT WITH WATER.

The curve *a* represents the variations of pressure, when there is no heating of the air.

pression. It corresponds to a mean pressure per square metre of 16,588 kilogrammes and 3164 kilogrammetres of work. The ratio of the work really expended to that which would have been, had the temperature remained constant, is expressed by the fraction

$\frac{3164}{3809} = 0{\cdot}830.$ Had there been no cooling of the air, the ratio of these two quantities, according to the figures given in our first table, would have been expressed by $\frac{16580}{21209} = 0{\cdot}78.$

Calculation shows that the temperature was 147° C. at the end of the stroke during which the diagram was taken; while it would have risen 195·3° had there been no loss of heat. In this calculation, we have supposed the temperature of the atmosphere to be 20° C. Machines for compressing in the presence of water, when this liquid is applied as in the machines at Seraing, therefore present but very little advantage on the score of cooling the air. Their inefficiency

ought, we think, to be attributed principally to the following fact, known ever since the experiments of Rumford, namely: that water possesses, in a slight degree only, the property of conducting through its mass, heat received on its upper surface. In the machine at Seraing, the air at the time of compression, rests on the water. The surface of the water is indeed heated, and from an increase of the temperature of the surface there results a decrease in its density, which makes it impossible for the thin superficial sheet of water at the top to be replaced by the colder water underneath. It is probable that the cooling, relatively of but little importance, which the air undergoes in the compressor at the Marie mine, is due, for the greater part, to its contact with the cast-iron walls of the cylinder, which are flooded at every return stroke of the piston.

Complete cooling of the air would be effected if it were put in contact during its compression with a liquid surface large enough. To obtain this surface we propose to inject into the compressor cylinder a certain quantity of water in the state of the smallest possible globules, that is, in the form of *water-spray.* The finer the spray and the greater the quantity introduced, the more certain will be the effect, but as it may be important in a practical point of view, that this quantity be a minimum, we proceed to indicate the method to be pursued in calculating it.

We accept as demonstrated the following facts:

(1) The quantity of heat contained in any volume of air, is proportional to its weight and temperature, and has no relation whatever to the tension.

(2) A cubic metre of air at the temperature of melting ice, and at the pressure of an atmosphere, taken equal to a column of mercury of 0·76 metre, weighs 1·293 kilogrammes.

(3) When a definite volume of air, whose tension remains constant, is caused to expand by the application of heat, the increase in volume which results is, for each degree C., the $\frac{1}{273}$ of the volume which the gas would occupy at zero. In this case the quantity of heat required is equal to the 0·2374 of that which would raise to the same temperature a weight of water equal to that of the air.

(4) When the air is maintained under constant volume, to produce a given increase in its temperature, a quantity of heat is necessary

equal to the 0·168 of that which would be needed to effect the same increase of temperature in an equal weight of water.[1]

(5) A thermal unit (*calorie*), that is, the quantity of heat necessary to raise 1 kilogramme of water, at zero, through 1° C., represents the quantity of heat necessary to yield 424 kilogrammetres of work.

We have seen above that a cubic metre of air, taken at atmospheric pressure, and the temperature of 20° C., requires, in order to be compressed to eight atmospheres and introduced into the reservoir, 21,422 kilogrammetres of work, assuming that its temperature remains constant; *i. e*, that the tension during the compression follows Mariotte's law.

This, theoretically, is the quantity of work expended by the steam engine performing the compression; but it is less than the work actually necessary, for atmospheric pressure comes to the aid of the steam and furnishes 10,334 kilogrammetres of work; so that a cubic metre of atmospheric air, compressed and in the reservoir, represents the work of $21422 + 10334 = 31756$ kilogrammetres. This work is made up of two parts:

(1) The quantity expended in bringing the air from atmospheric pressure, to that (the pressure) of the reservoir.

(2) The work necessary to force the air into the reservoir.

This last quantity is equal to $V P$; V being the volume occupied by the air at the moment when its tension equals that of the air in the reservoir. In case the latter be eight atmospheres, the work expended to force the air out of the cylinder is:

$$10334 \times 8 \times 0{\cdot}125 \text{ m.} = 10334 \text{ k}^{\text{m}}.$$

The work necessary to bring the air to the tension of the reservoir is, therefore:

$$31756 - 10334 = 21422 \text{ k}^{\text{m}}.$$

When the air is taken from the atmosphere, its temperature is 20° C. Since we assume that the compression is to follow Mariotte's law, it will still possess this temperature when its tension has attained that of the air in the reservoir; *i. e.*, when its volume is reduced to 0·125 cubic metre. The air has, therefore, neither gained nor lost in

[1] Physicists are not quite agreed as to the value of the specific heat of air under constant volume. But even an important difference between the real coefficient and that of 0·168, here assumed, would affect only very slightly the results of the calculations, as we find further on.

heat, but we have expended upon it, in order to compress it, 21,422 kilogrammetres of work. Now as no work can disappear without the production of heat, we must admit that, to keep the temperature constant during compression, it is necessary that $\frac{21422}{424} = 50{\cdot}52$ thermal units be absorbed.

It is doubtful whether we can, in practice, by the aid of water-spray, exactly maintain the temperature of the air at 20° C., chiefly on account of the slight difference ordinarily existing between the temperature of the surrounding air and that of the water used for cooling. We believe that it is agreed that the temperature of the air during compression is higher by a certain quantity than that of the atmosphere.

If we suppose, for example, that with water at 15° C. we cannot lower the temperature below 39° C., the compression will not at first follow Mariotte's law, but only from the moment when it has attained the temperature which coincides exactly with a tension of 1·25 atmospheres. The compression to eight atmospheres, of a cubic metre of air under these conditions, calls for 22,711 kilogrammetres of work, equivalent to $\frac{22711}{424} = 53{\cdot}56$ thermal units; but a part of this heat is employed in raising the temperature from 20° to 39° C.

It is equal to $1{\cdot}199 \times 0{\cdot}168\,(39 - 20) = 3{\cdot}83$ thermal units, 1·199 being the weight in kilogrammes of a cubic metre of air at atmospheric pressure and 20° C., so that the heat to be absorbed amounts to $53{\cdot}56 - 3{\cdot}83 = 49{\cdot}73$ metric thermal units. Each kilogramme of water which we introduce into the compressor at 15° C., absorbs $39 - 15 = 24$ thermal units. It is therefore necessary to use $\frac{49{\cdot}53}{24} = 2{\cdot}062$ k^{g}. of water.

(To be continued.)

New Alloy of Iron.—Sideraphthite is composed of 66 parts of iron, 23 of nickel, 4 of tungsten, 5 of aluminum, 5 of copper. It is not attacked by sulphureted hydrogen, or by vegetable acids, and is only slightly corroded by mineral acids. It is more useful than silver, and may be prepared at less expense than German silver. It seems likely to supplant many of the alloys which require plating to prevent oxidation.—*Les Mondes*, April 12. C.

Chemistry, Physics, Technology, etc.

ON THE DEVELOPMENT OF THE CHEMICAL ARTS, DURING THE LAST TEN YEARS.[i]

By Dr. A. W. Hofmann.

From the *Chemical News*.

[Continued from Vol. ciii, page 334.]

Utilization of Burnt Ores.—In the French department of the Vienna Exhibition the chemical works of the company St. Gobain, Chauny and Cirey, displayed iron obtained from non-cupriferous burnt pyrites. The thorough roasting of the pyrites, which makes it capable of being worked for iron, is said to have been effected by allowing the smalls to cool in thin layers, and roasting them repeatedly in Perret's furnace. The burning was effected by charging the plates alternately with burnt and with green ore. The hot gases evolved from the green smalls play over the plates charged with burnt ore and effect a second roasting.

In 1859, List pointed out the existence of zinc in the iron pyrites of the "Sicilia" mine.[ii] P. W. Hofmann ascertained that this zinc is present in the burnt ore in the state of sulphate, and extracted it by systematic lixiviation.[iii] The solution thus obtained, sp. gr. 1·25, consists almost entirely of sulphate of zinc along with a little copperas. It is heated to about 40° and mixed with common salt in equivalent quantity. Thus there is produced a solution of sp. gr. 1·38, which, on cooling, deposits sulphate of soda in sufficient quantity to cover all expenses. The mother-liquid is concentrated to 1·60 sp. gr., and the chloride of zinc thus obtained, containing mere traces of sulphates and of iron, is sold either in the liquid or the solid form. According to P. W. Hofmann's account large quantities of zinc chloride are thus obtained at Wocklum, from the sulphur ores of the "Sicilia."

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[i] "Berichte über die Entwickelung der Chemischen Industrie Während des Letzten Jahrzehends."

[ii] List, *Tech. Chem. Mittheilungen.* Hague, 1859.

[iii] P. W. Hofmann, private communication.

Richters[i] shows to what extent and under what circumstances the smelting of ores so rich in sulphur as are burnt pyrites in Germany, could, from a chemical point of view, prove successful. In fact, many attempts have been made to utilize the burnt ores for the production of crude iron, but none of the methods proposed have found acceptance. In England the burnt Spanish, Portuguese and some of the Norwegian pyrites are used after roasting. Wedding and Ulrich have carefully studied and described the treatment of burnt ores in England.[ii]

The burnt ore is sold by the chemical works to copper smelters with an average percentage of 3·66 sulphur, 58·25 iron, and 4·14 copper. It is first ground, then mixed with 15 to 20 per cent. of salt, and submitted to a chlorinized roasting in reverberatories or muffle furnaces. The gases evolved are condensed in a coke tower through which water flows, thus furnishing a mixture of hydrochloric and sulphuric acid. The copper is converted by roasting into a soluble chloride, which is extracted first with water and then with the acid mixture from the condensation tower. The copper is then precipitated by iron. After nine successive lixiviations the residue contains merely from 0·08 to 0·2 per cent. of copper, and 0·16 to 0·25 of sulphur, and is smelted for iron in blast furnaces as "purple-ore." A part is also used in lining the puddling furnaces, and another small portion is reduced with coal to the state of spongy iron, and then serves to precipitate metallic copper from its solutions.

Claudet[iii] patented a process in England for recovering the silver which is dissolved in the saline liquors as silver chloride by precipitation with iodide of potassium. His process is even applicable to ores containing merely 0·027 per cent. of silver. The liquors formed by extracting the roasted ores with water contains 95 per cent. of all the silver present; from these liquors the silver is precipitated to the extent of about 11·6 grms. per ton of ore. The net profit amounts to two shillings per ton of ore, giving at the Widnes copper works a yearly return of £3000.

When coal in Lancashire cost 5s. per ton, Phillips,[iv] after extracting the copper, precipitated the iron, and obtained fine sulphate of soda

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[i] Richters, *Dingler*, cxcix, 292.

[ii] Wedding and Ulrich, *Zeitsch. Berg. Hutten. u. Salinen w.*, xix, 292.

[iii] Claudet, *Chem. News*, 1871, 181.

[iv] Private communication.

by evaporating the mother-liquor. At the present price of coal this process has been abandoned.

The chemical works of Aussig and Griesheim exhibited at Vienna large quantities of thallium. This metal is obtained from the flue dust formed on burning pyrites, deposited between the kilns and the chambers. Max Schaffner[i] describes the process employed at Aussig. The flue dust is repeatedly boiled in water acidulated with sulphuric acid, and from the filtered solution the metal is precipitated on the addition of hydrochloric acid as impure thallous chloride. The precipitate is washed with cold water and converted into sulphate by heating with concentrated sulphuric acid. The sulphate is then dissolved in water and again mixed with hydrochloric acid, which precipitates tolerably pure thallous chloride. This is again treated with sulphuric acid, and the sulphate is reduced with pure metallic zinc. The metallic sponge thus obtained is washed with well-boiled water, dried between blotting paper, and melted over the lamp in a porcelain crucible, into which a stream of coal-gas or of hydrogen is conducted.

Roasting of Various Metallic Sulphides.—At Freiberg and in the Harz, galena is used for the manufacture of sulphuric acid, and is roasted for this purpose in large wide shaft-furnaces containing 250 cwts. The ore gives off the half of its sulphur and yields a gaseous mixture containing 4 to 6 per cent. of sulphurous acid.

Copper pyrites are used for making sulphuric acid both at Chessy and at Oker in the Harz, and are roasted for this purpose in small tubes. At Mansfield also copper ores are desulphurized in kilns, the Gerstenhöfer furnaces introduced for this purpose having been abandoned. In Swansea, on the other hand, the ground ore is roasted in Gerstenhöfer furnaces, which are there found to work satisfactorily. The lead chambers at Swansea are at the distance of about 20 metres from the furnaces, so that the greater part of the flue dust is deposited before reaching the chambers.

In the "Report on the London Exhibition of 1862," Dr. A. W. Hofmann[ii] mentions that Lawes, of Barking Creek, on the Thames, employs in the manufacture of sulphuric acid the oxide of iron which has served for the purification of coal-gas, and which has become rich

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[i] Schaffner, *Sitzb. d. k. Akad. d. Wissenschaft.*, 53, Feb.; *Wagner Jahresber.*, 1871, 1.

[ii] A. W. Hofmann, "Report by the Juries," 1862, 15.

in sulphur. This so-called "Laming's mass" is now also used by the St. Gobain Company, of Aubervilliers, near Paris; by Seybel, of Liesing, near Vienna; by Kunheim and Co., of Berlin, and probably also elsewhere. The roasting is conducted partly upon earthen plates, partly in furnaces with narrow grates, the gases obtained being well suited for the manufacture of sulphuric acid.

Zinc blende has found of late years a more extended employment in the manufacture of sulphuric acid, and its use will probably be further extended. The chemical works "Rhenania," at Stolberg, near Aachen, may claim the merit of having thoroughly studied the utilization of the gases escaping on roasting zinc blende, and of having carried the process out in the most complete manner. Twenty years ago blende was roasted at Stolberg in a reverberatory furnace of two stages, according to F. W. Hasenclever's patent. The upper hearth formed a muffle constructed of vaults, in which the blende underwent a preliminary roasting, the sulphurous acid evolved being passed into the chambers. The roasting of the ore was then completed on the lower hearth. When pyrites were cheap it was not remunerative to use blende, as the desulphurization remained imperfect and gases too poor in sulphurous acid entered the chambers. The simple muffle-furnace was improved by Eugene Godin, whose plan did not come into operation at Stolberg until 1865, after his death. The ores, before arriving upon the hearth of the reverberatory heated by the products of combustion, pass over seven plates of fire-clay, arranged one above another. The spent ores are withdrawn below, the charge of the second is removed to the first, and that of the third to the second, etc., and green ore is thrown upon the seventh. In this furnace the roasting took place in a satisfactory manner, and the gases were rich in sulphurous acid. Labor, however, was high, and the loss of gas whilst charging was considerable. If the draft was increased the gases were too much diluted by the entrance of air at the doors.

In 1866 the Gerstenhöfer furnace was introduced at Stolberg for roasting zinc blende and used for some time. At the best it only succeeded in utilizing half the sulphur of the blende. On the other hand, the amount of flue dust (the blende there in use being very finely granular) was excessive, so that this furnace has proved as little adapted for roasting blende at Stolberg as at Borbeck and Swansea.

(To be continued.)

THE FLOW OF SOLIDS.

By Lewis S. Ware, C. E.

It is a comparatively recent discovery that solids as well as liquids are possessed of fluidity under favoring circumstances, but the investigations in this direction have not been numerous. Much attention was given to this subject by M. Tresca of the Conservatoire des Arts et Métiers in Paris. Having witnessed some of his experiments and seen the results of others, I have thought a statement of them would be of interest to the general reader and of value to workers in metal, who, though most frequently using solids not in this condition, yet very often having to deal with this flow, it is highly important that they should know the laws which govern it. These laws are but little known, and for that reason the experiments of M. Tresca, will help to fill a space up to the present time greatly neglected. Those who visited the Centennial Exhibition saw various machines used in piercing iron, even in plates several inches thick, apparently with great ease. I have thought it well to divide the subject into two parts.

Part I.—*Practical Experiments.*

If a cylinder of lead, three inches long, be placed between two iron plates, having each a hole $\frac{3}{4}$ of an inch in diameter, the holes opposite each other; if we cause a punch to pass through first hole (plate 1) penetrating the cylinder of lead, causing the expelled portion L to pass through the second hole in plate 2; the portion expelled will be found to have for its dimensions $\frac{3}{4}$ of an inch in diameter and one inch in height, instead of three, as should have been if the derangement of the matter had taken place in the direction of the movement.

1st Experiment.

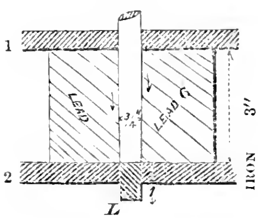


Fig. 1.

This phenomenon could be explained by supposing a different density, for the compressed portion ; upon examination this hypothesis

is found to be erroneous, and M. Tresca was the first to discover the true reason. His experiment (Fig. 2) consisted in placing, instead of a leaden cylinder *C*, a series of plates of the same metal.

M. Tresca's 1st Experiment.

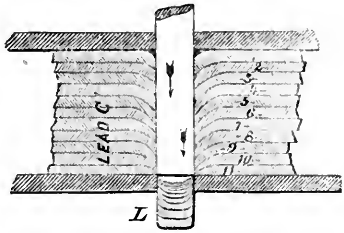


Fig. 2.

The punching was again begun, the portion expelled (*L*) is composed of unequal layers, each of which represents the plates (1, 2, 3, etc.). Those of the upper portion, except the first are extremely thin and hardly visible to the eye.

We can conclude from this, that portions coming in contact with the punch, were forced back into the layers of lead. This gave the first hints of internal movements that may take place from pressure on solid masses.

2d Experiment.

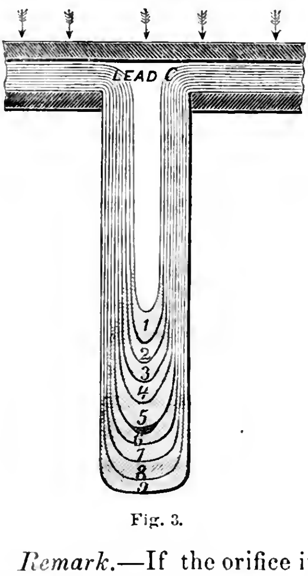


Fig. 3.

Flowing of the cylinder C *through a concentric orifice* (Fig. 3).

This experiment is very much the same as those we have just examined, a piston taking the place of the punch; pressure being applied, the lead escapes through a circular orifice, having the same centre as the axis of *C*. We have here a jet, the shape of which is a cylinder, enabling us to obtain information in regard to the internal changes taking place in *C*.

Remark.—If the orifice in the last experiment had been a polygon instead of a circle, we should have obtained a jet, the shape of which would have been that of a polygon, having the same number of sides as the orifice; these sides become smaller, and the angles more rounded, as we approach the centre, where they are replaced by an almost perfect circle. Here is a phenomenon exactly the same as the one observed by M. Bazin, in his researches on the transverse sections of flowing liquids.

When the height of the cylinder C (Fig. 4) is less than the radius of the orifice, there is an internal cavity in the jet, the shape of which is extremely regular, so much so, that it can easily be expressed by an equation. If we observe what takes place when the pressure becomes still greater, it will be seen that the external appearance of the jet (Fig. 5) is the same as that of a liquid (contraction of the vein). This is the only experiment that "M. Tresca" showed me in which this phenomenon was visible.

3d Experiment.

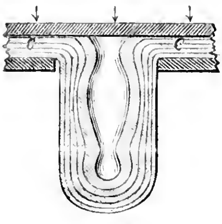


Fig 4.

The next two show more and more the great similarity existing between the laws of flow of liquids and solids.

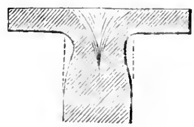


Fig. 5.

They differ from those we have examined, in the shape given to the metal before being submitted to a pressure. Instead of plates placed one on the other, they are *concentric cylinders*. If a section through the axis of the entire mass be examined after the pressure has had its effect, it will be seen that all the molecules composing C have a tendency to move in the direction of the orifice, after which they move parallel with each other.

4th Experiment.

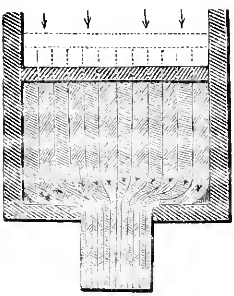


Fig. 6.

Remark.—It is a well known fact, that all calculations concerning liquids, are based on the hypothesis of parallelism of the molecules in movement.

The external appearance of the vein (owing to the influence of the air friction, etc.), has a tendency to mislead the observer.

5th Experiment.

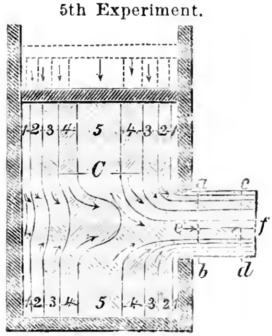


Fig. 7.

Flowing of C *through a lateral orifice.*

When the pressure is exerted on the upper part of C, it is transmitted to the interior of the mass, causing a jet to form, having a cylin-

Vertical section of jet.
Section A B.

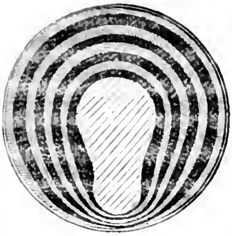


Fig. 8.

Fig. 9.

Section C D.

drical shape, offering many interesting peculiarities. If sections be made perpendicular to the axis of the jet, it will be seen that (1), (2), (3), etc., form each a distinct portion of the total. If Figs. 8 and 9 be examined it will be found that this jet is composed of two distinct parts, one corresponding to the superior, and the other to the inferior portion of *C*.

The existence of the above can be better realized if a section perpendicular to the orifice be made (see Fig. 10).

Section E F.

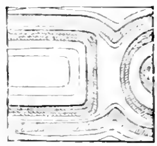


Fig. 10.

All this movement takes place with great regularity, as shown by Figs. 8, 9, and 10.

Part II.—*Theoretical Calculations.*

I will now endeavor to show what takes place during the period of pressure; the argument will be based on two hypotheses, after which I will give an experiment, also made by M. Tresca, expressly for the purpose of determining how near these theoretical calculations are to the actual fact.

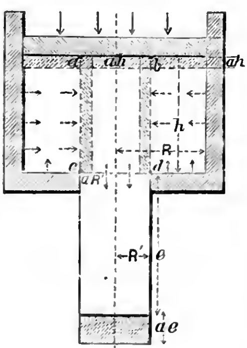


Fig. 11.

I have already stated, that the volume of the jet, added to that of the cylinder, forms a quantity that is constant before and after the pressure. In other words, a decrease of *C* will correspond to an increase of the jet, the density through the entire mass remaining the same, if we suppose that R is the radius of *C*, and R' radius of orifice, h height of *C* at any moment during the pressure, H height of *C* before pressure, l length of jet corresponding to a pressure $(H - h)$.

If we suppose a small decrease $(-d\,h)$ in the height of h, corresponding to an increase $(d\,l)$ in the jet, these volumes being the same, we have:

$$-\pi R^2 \, d\, h = \pi R'^2 \, d\, l, \quad \ldots \quad (a)$$

hence,

$$d\, h = -\frac{R'^2 \, d\, l}{R^2}. \quad \ldots \quad (1)$$

The equation (1) is necessary in our future calculations.

FIRST HYPOTHESIS.—Concentric contraction of the central cylinder ($a\ b\ c\ d$), having a radius $R' =$ to the radius of the jet.

If we admit the existence of a central cylinder, we shall have a ring which is the remaining portion of C, having R' for its interior, and R for its exterior radius.

If a pressure be exerted on the upper part of C, at every decrease of $h = d\, h$, the matter composing the ring, not being able to make its escape either in the direction of the pressure, or through the sides (the latter being sufficiently strong to resist it), will have its effect on the central cylinder $a\ b\ c\ d$.

The pressure on all sides being the same, we will not be far from the truth in saying that this *central cylinder* is transformed into a new surface of revolution, having the same axis as before. The most simple of all, is to suppose that it is still a cylinder. In this hypothesis it must be admitted that a decrease of the volume of the ring, when its height is diminished $-\, d\, h$, is compensated by a corresponding increase resulting from the decrease of R' of a quantity $= d\, R'$.

$$\pi\, (R^2 - R'^2)\, d\, h = 2\, \pi\, R'\, d\, R'\, h,$$
$$(R^2 - R'^2)\, d\, h = 2\, R'\, d\, R'\, h.$$

Hence,

$$\frac{d\, h}{h} = \frac{2\, R'\, d\, R'}{R^2 - R'^2}. \quad \ldots \quad (2)$$

SECOND HYPOTHESIS.—Proportional contraction of the central cylinder.

This central cylinder, $a\ b\ c\ d$, cannot have its radius diminished unless certain movements take place in the interior of a second *central cylinder* concentric to the first, having a radius r.

All actions being exerted in an equal manner around its axis, we can admit that this cylinder, having a radius r, will be modified in its transverse section proportionally to the one it primarily had. Hence,

$$\frac{d\, (\pi\, r^2)}{\pi\, r^2} = \frac{d\, (\pi\, R'^2)}{\pi\, R'^2} \text{ or } \frac{d\, r}{r} = \frac{d\, R'}{R'}. \quad \ldots \quad (3)$$

Equation of the locus described by any given point of the convex surface of the central cylinder, having a radius R':

To obtain this equation, it will be necessary to eliminate h, $d\,h$, $d\,R'$, between the equations (1), (2), (3). This is done in the following manner:

If we find the integral of (a), we have $R^2\,h = -R'^2\,l + C$, but when $h = H$, we have $l = o$; this gives $R^2\,H = C$. Hence,

$$h = \frac{R^2\,H - R'^2\,l}{R^2} \qquad \text{(b)}$$

If we divide (1) by (b), we will have,

$$\frac{d\,h}{h} = \frac{\dfrac{R^2\,d\,l}{R^2}}{\dfrac{R^2\,H - R'^2\,l}{R^2}} = -\frac{R'^2\,d\,l}{R^2\,H - R'^2\,l}. \qquad \text{(c)}$$

If from (3) we obtain the value of $d\,R'$, and substitute this in (2), it will give,

$$\frac{d\,h}{h} = \frac{2\,R'^2}{R^2 - R'^2}\;\frac{d\,r}{r} = -\frac{R'^2\,d\,l}{R^2\,H - R'^2\,l}.$$

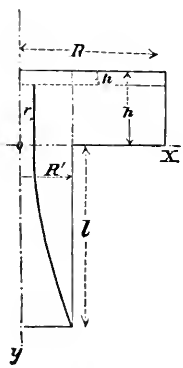


Fig. 12.

Hence, by integration, we have:

$$\text{Log}\,'r = \frac{R^2 - R'^2}{2\,R'^2}.\quad \text{Log}'\,\frac{(R^2\,H - R'^2\,l)}{R^2\,H} + C, \qquad (4)$$

but when $r = R'$, we have $l = o$; this gives,

$$\text{Log}'\,R' = \frac{R^2 - R'^2}{2\,R'^2}.\quad \text{Log}'\,R^2\,H + C. \qquad (5)$$

If we subtract (4) and (5), we have,

$$\text{Log}'\,r - \text{Log}'\,R' = \frac{R^2 - R'^2}{2\,R'^2}.\ \text{Log}'\,(R^2\,H - R'^2\,l)$$

$$-\,\text{Log}'\,R^2\,H;\ \text{or,}$$

$$\text{Log}'\,\frac{r}{R'} = \frac{R^2 - R'^2}{2\,R'^2}.\quad \text{Log}'\,\frac{(R^2\,H - R'^2\,l}{R^2\,H}. \qquad (6)$$

This equation can be written in the following manner:

$$\frac{r}{R'} = \frac{(R^2\,H - R'^2\,l)}{R^2\,H}^{\frac{R^2 - R'^2}{2\,R'^2}}.$$

The equation (6) can be written under another form more convenient for the study of the curve it represents:

$$\text{Log}'\,\frac{r}{R'}\,\frac{2\,R'^2}{R^2 - R'^2} = \text{Log}\,\frac{R^2\,H - R'^2\,l}{R^2\,H},$$

or

$$\left(\frac{r}{R}\right)^{\frac{2\,R'^2}{R^2 - R'^2}} = \frac{R^2\,H - R'^2\,l}{R^2\,H}.$$

This curve having for its axis of co-ordinates $o\,x$ and $o\,y$, r will be the abscissa and l the ordinate. Hence (see Fig. 12),

$$\left(\frac{x}{R}\right)^{\frac{2\,R'^2}{R^2 - R'^2}} = \frac{R^2\,H - R'^2\,y}{R^2\,H}.$$

Discussion.—The nature of this curve varies with the exponent $\frac{2\,R'^2}{R^2 - R'^2}$. If $R'^2 = R^2 - R'^2$, or $R'^2 = \frac{R^2}{2}$, the curve is a parabola of 2d degree; if $2\,R'^2 = R^2 - R'^2$, or $R'^2 = \frac{R^2}{3}$, we shall have a right line. All quantities given to $2\,R'^2$ smaller than $(R^2 - R'^2)$, the curve will be a hyperbola, the degree of which is variable and becomes of the 2d degree, when $2\,R'^2 = -(R^2 - R'^2)$. But we should then have $R'^2 = -R^2$, which would give for R' an imaginary quantity.

Experimental Verification (Fig. 13).—The cylinder C is composed of two kinds of plates; the lower two occupying the total space having a radius R: those placed on top being rings, their exterior radius is R, and interior, R' = to the orifice = 0 5 of an inch.

Experimental Verification.

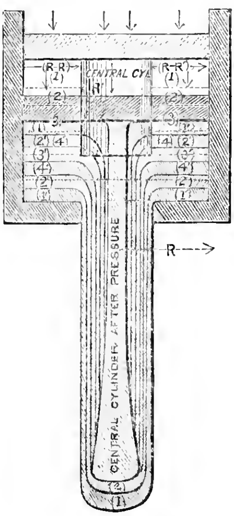


Fig. 13.

In this open space having a radius R', M. Tresca placed a cylinder of lead exactly fitting (this representing the supposed central cylinder). After the pressure had been exerted, a vertical section was made through the cylinder C and the jet; thus permitting a comparison between the theoretical equation and the actual fact.

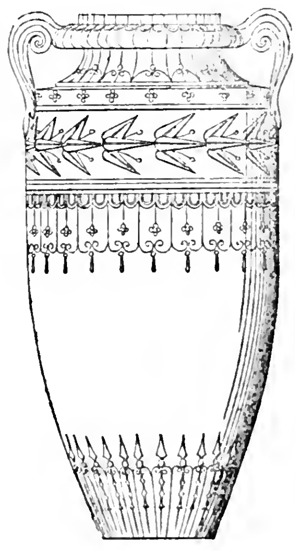
In all the experiments made by M. Tresca, no difference greater than $\frac{1}{30}$ of an inch was found.

This verification is a strong proof of the exactness of the theory of the flowing of solids.

CERAMICS.

[Abstract of the closing lecture in Prof. Pliny E. Chase's course on "Lessons of the Centennial," delivered before the Franklin Institute, March 20th, 1877.]

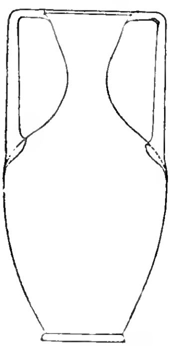
One of the most important results of the London "World's Fair," in 1851, was the establishment of the South Kensington Museum. Liberal contributions having been made for the purchase of artistic works which would be typically representative, and æsthetically instructive, the attention of the directors was immediately and instinctively turned to the nations of Eastern Asia. Living near the birthplace of civilization, trained by long ages of unquestioning faith in the simple intuitions of taste, feeling and daring, rather than deliberating and contriving, the Mongolian artists had been educated, by the "second nature" of habit, to a remarkable delicacy of judgment in the harmonious blending of colors, and in the expression of ideals by graceful or appropriate forms.

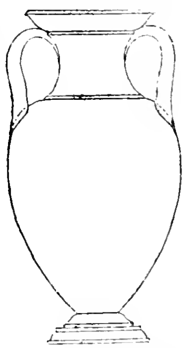


The readiness with which ceramic[1] wares can be moulded and painted, rendered them fit vehicles for the display of artistic skill. We accordingly find, in all ornamental collections of Chinese and Japanese goods, that articles of china and porcelain hold a prominent place. It is, however, by no means certain that the earliest crockery was Asiatic. Potsherds have been found in Egypt at a depth of 39 feet below the surface, and some geologists, judging from historical data bearing upon the rate of the Nile deposits, have assigned them an antiquity of 13,500 years. The uncertainty of such estimates is shown by the late discussion between eminent geologists and astronomers, the former claiming at least a hundred million years since the deposition of the oldest rocks of the globe, while the latter claim that fifteen million years is the greatest supposable interval since the earth began to condense from the primitive nebular chaos.

[1] From the Greek word *Keramos*, "potter's clay;" *Kerameikos*, "made of clay."

Even among the most savage tribes of men, wherever there was a clayey soil, its plasticity and its property of hardening in the sun must have been early observed. Cooking utensils, when exposed to the fire, would be still further hardened, so that the potter's art may have grown from a number of independent centres. We find it recorded in Genesis, xi, 3, that the people "said one to another, Go to, let us make brick, and burn them thoroughly." This is supposed to have been about 2247 B. C., and we may probably assign to the same period many of the Assyrian and Babylonian tiles and cylinders which have been discovered within the last half century, some of which served as books for circulation, or for library reference, some as records of land titles, or of historical events, some as evidences of bankers' credits, or as currency for effecting exchanges in the channels of trade. The "cuneiform," or wedge-shaped letters of the old Assyrian and Persian alphabets, owe their peculiar configuration to the ease with which they could be cut by the graver in the soft clay. Earthen vessels are expressly mentioned in Leviticus, vi, 28, and xi, 33, about 1490 B. C. Some of the early Phœnician vases, which display much grace of outline and tasteful ornamentation, are assigned to the same period.

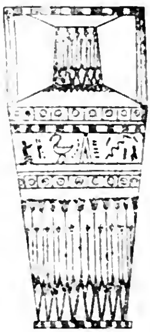




In common pottery, the clay is mixed with marl or sand before being baked. The usual red color is due to minute portions of iron ore, which oxidize in the fire. Pipe-clays, and such as are used for the Milwaukee brick or for firebrick, are free from iron, and they are therefore whitish or cream-colored after being burnt. The earliest forms of earthen vessels appear to have been derived from gourds, and some antiquarians have amused themselves by searching out the particular species which have been most often copied in different nations. At first the moulding was done by hand, as in this mummy-vase from the Ibis pyramid of Sakkara, and in this Cherokee dinner-pot. But at a very early period, the potter's wheel was invented, from which Jeremiah drew his instructive lesson: "Then I went down to the potter's house, and behold, he wrought a work on the wheels; and the vessel that he made of clay was marred in the

hand of the potter: so he made it again another vessel, as seemed good to the potter to make it." On Egyptian monuments which are supposed to be nearly 4000 years old, the potter's wheel is depicted, of the same form as is used at the present day.

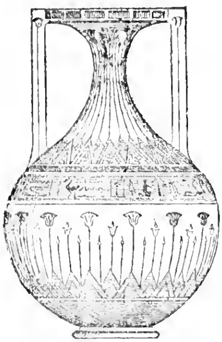
Messrs. Galloway & Graff have kindly sent us one of their wheels, with skilful workmen to perform the operation of "throwing" or shaping jugs, vases, and crocks of various kinds. See, as the wheel spins round, under the impulse of the treadle, how the shapeless mass of clay follows, as if by magic, the dexterous fingers of the craftsman, until, almost with the speed of thought, the finished vase stands before you in all its beautiful symmetry. See, also, as he cuts this jug in two with his slender wire, how uniform is the thickness of the clay, and how closely the inner and outer surfaces correspond in all their details of form. See, again, as new forms start into being, more swiftly than my words can follow them, how the vessel that was marred is made "again into another vessel, as seemed good to the potter to make it."



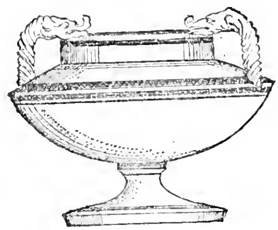
Although modern ingenuity has been unable to improve the potter's wheel, it has devised some useful subsidiary processes. Thus, with a turning lathe, the operation of "shaving" may be performed, not unlike the process of spinning metals, that I described to you in my last lecture, yielding more intricate shapes than can be readily got from the simple wheel; by "pressing" into plaster moulds, as the journeyman is now doing in this mould for a hanging basket, copies of approved works can be easily multiplied to any desired extent, and exquisite statuettes, like this reduction of the Venus of Melos, or fac-similes of the most graceful antique vases, like those upon the table, can be brought within the reach of moderate purses; by carefully selecting, drying, pulverizing and sifting the clay, and mixing it with gum water, a plastic paste may be formed of peculiar delicacy and tenacity, fitted, like wax, for the representation of fruits and flowers in their minutest details. The workman, as you see, first dips his fingers in oil, in order to prevent the adhesion of the clay, and then deftly shapes stem and stamen, and petals and leaves, until presently the completed flower is seen, delightfully representing some of the most beautiful forms of nature, with all their grace and expressiveness. Place this gray handiwork in the kiln, until the

fire permanently imparts a portion of its own ruddy glow, and you will have a bouquet fit for the table of a queen. You have all, doubtless, been gratified with the evidences, already furnished by our shop windows, of the educating influences of the Centennial. I am sure that your gratification will be increased by finding that the good taste of our manufacturers is turning them to such practical account.

Ceramic or fictile wares are classed as "soft" or "hard." The former division embraces all of the earliest forms of pottery, terra cotta, and such earthenware, of any description, as can be readily cut or scratched by a knife; the latter includes stoneware, queensware, porcelain, and other similar wares which have a steel-like hardness. In each division there are various degrees of hardness,



depending partly upon the materials, partly upon the degrees of heat to which the articles are exposed in the kiln. In my first lecture, I described glass to you as being both a salt and a soap, and I gave you ocular demonstration of its use in the latter capacity. Pottery may be regarded, in a similar manner, as sand soap, for it consists of alkaline silicates, with a mechanical mixture of earth or sand.

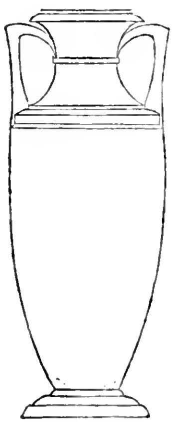


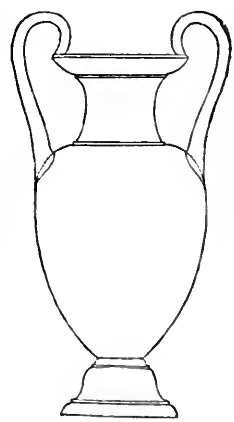
One of our most valuable artificial cements, common mortar, is, like pottery, an alkaline silicate, being mainly a silicate of lime. The thoroughness with which the ingredients are blended, and the hardness and durability of the result, are well shown in the aqueducts and sewers of Rome, which have stood since the days of the Tarquins. Nature, in some of her most valuable gems, has effected combinations closely analogous to those which our best ceramic manufacturers seek to accomplish by the more speedy action of their fires.

Soft pottery may be either unglazed, glazed, lustrous, polished, varnished or enameled. These distinctions are most strikingly and characteristically marked, in the Etruscan or Græco-Roman *fictilia*, made between 800 B. C., and 350 B. C. The most beautiful forms are supposed to have been borrowed from Asia, and with good reason, as you may convince yourselves, by comparing the fac-similes of

vases found by Dr. Schliemann in the supposed ruins of Troy, with the vases upon the table. The ground was most often reddish brown, but sometimes fawn-colored, orange, ashy gray or black; the two latter colors being, perhaps, attributable to asphaltum, the others to iron. The ornamental figures were white, black, brown, red or yellow, consisting, in some of the most highly valued specimens, of mere outlines, scratched in the clay with a pointed instrument. In the best periods, and in the most satisfactory work, they were never raised above the surface, the pure taste of the designers shrinking from anything that would mar the severe dignity of the outline. The Greeks struck medals and erected statues to ceramic artists. The greatest sculptors and the noblest architects worked with potters, and designed for them; therefore, many of the sculptured, and some of the painted vases, were among the most justly prized works of the highest art that the world has ever seen.

Glazed or enameled surfaces, like this image of a mummy, were made in Egypt as early as the 4th dynasty, between 2000 and 3000 years B. C. You have all heard the story of the Phœnician sailors, who kindled a fire on the beach to cook their dinner, and, after it was over, found glass in the ashes. The tale is likely enough, for beach sands are commonly siliceous, and sea-weeds abound in soda, so the materials and the heat that were needed to make silicate of





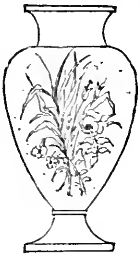
soda, or glass, were at hand. But the discovery may have been independently made, in many different times and places. The yellow color of lamp-flames is mainly owing to the soda that is in the flame. Bricks and pots are often glazed when the heat is intense, without any special preparation. The simplest mode of glazing is by throwing a little salt into the kiln. The salt is decomposed by the heat, its chlorine escapes, and the soda remains in a state of vaporous diffusion, just in a fit condition to open new combinations and assume new orbits of oscillation. It therefore readily unites with the silicon

of the clay, and forms a transparent glass surface. Enamels with metallic oxides, copper for blue, and tin for white, were used on bricks and vases at a very early date in Babylonia and Assyria, and some Chinese writers claim the manufacture of porcelain, as early as 3200 B. C. Stanislaus Julien, however, thinks this was merely stoneware, and that there are no authentic records of any porcelain resembling the modern wares, earlier than 185 B. C. It is not unlikely that the arts of cloisonné and champ levé enameling may have been known at a much earlier date.

Philostratus, a Greek, who established himself in Rome in the early part of the 3d century, at the wish of Julia, wife of Septimius Severus, in his "Treatise on Images," writes: "It is said that the barbarians living near the ocean, pour colors upon heated brass, so that they adhere, become like stone, and preserve the design represented." The Castellani collection contained exquisite specimens of ancient enamels; the Italian and French departments, and especially the exhibits from Limoges, of modern enamels. The *champ levé* process, in which the ground for the paste is cut out of the solid metal, leaving slender outlines for the design, seems to be more modern than the *cloisonné*, and much less difficult. The best works of this kind were executed in the 12th century. The Japanese appear to have improved upon their teachers, the Chinese, by cementing the cloisonné filigree to a porcelain body. The Chinese, French and English, have all successfully adopted the improvement, and Elkington's porcelain cloisonnés left nothing to be desired, either for perfect execution, taste of design, or harmony of color. The Hindoos are still wonderfully proficient in the art of enameling on metals.

The Saracens brought to Europe the secret of applying enamel colors to tiles and vases, using both the transparent lead and the opaque tin enamels. They conquered the Balearic Isles in 798, and established potteries in Majorca, which was conquered by James I, King of Aragon, in 1220, and united to Spain in 1375. The manufacture of pottery was continued under Christian rule, and the ware was called majolica, from the name of the island. All true majolica is "soft," the resemblance to harder wares being due to the opacity of its enameled surface. About A. D. 1430, Luca della Robbia cast his large circular *rilievos* and statues in potter's clay, fired and glazed them, and applied them as sculptures to Florentine buildings.

The first period of majolica proper, or mezzo-majolica, was from 1450 to 1500. The forms and ornamentation were stiff and often grotesque. During the second period, from 1500 to 1560, the wares reached their highest excellence, the most celebrated factories being at Pesaro, Gubbio, Castel Durante and Urbino. In 1509, Jacques Lanfranco, of Pesaro, received from the Duke of Urbino, his patent for "the application of gold to the Italian faience,"[1] giving a



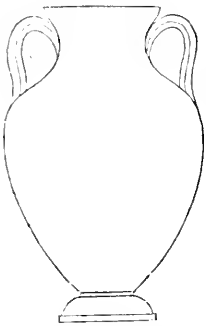
peculiarly brilliant prismatic lustre. In 1511, and subsequently, "Maestro Giorgio" Andreoli of Gubbio, improved upon Lanfranco's invention, giving his wares an inimitable ruby glow; but the secret of his process died with him. Near the close of the period, finer clays were used, more care was observed in all the processes of manufacture, and the

name "porcellana," signifying "little pig," was given to the product. This name is said to have been first applied to cowrie shells, from the resemblance of their shape to a pig's back, and transferred to the majolica on account of its beautiful white shell-like gloss. This early porcellana is sometimes called Raffaelle ware, from the idea that the great artist decorated the plates with his own hands, but the earliest specimens were not made until about twenty years after his death. Many of his designs, however, as well as those of Julio Romano and Marc Antonio, were employed, together with graceful figure compositions from the Bible and old mythologies, often surrounded by imaginative arabesques.

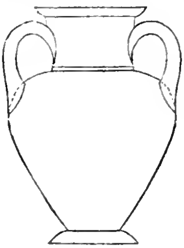
During these two periods an earthenware with a strong green glaze was manufactured in Germany (A. D. 1473); a very cheap, gaudily colored, rudely designed, but serviceable ware, at Delft, in Holland (A. D. 1500); the fine French Oiron or Henri-Deux ware, of which less than forty specimens are believed to be in existence (*ca.* A. D. 1520); and the Palissy ware. You know the story of Bernard Palissy; the poverty and misery and repeated failures that saddened his humble home at Saintes; the sixteen years of patient experiment, marked and sustained by a courage which did not flag even when he was obliged to burn his furniture in order to feed his furnaces; the

[1] A term supposed to have been derived either from Faenza in Italy, or from Fayence in France.

sturdy independence of his determination to work out everything for himself, though he might have learned much from the Italian factories; the beautiful forms, exquisite ornamentation, and close imitation of nature, which ultimately brought him the highest patronage, in spite of the inferiority of his material and the frequent coarseness of execution.



The hard pottery is sometimes divided into fine earthenware and stoneware. The semi-transparent variety, which was made in China at a very early date, is thought to have reached perfection about A.D. 1000. Its manufacture was described by Marco-Polo, in the fourteenth century, but it was not generally introduced in Europe until the Portuguese began trading with China, early in the sixteenth century. The principal ingredients used in the paste, are called by the Chinese "kao-lin" and "pe-tun-tse," both of which are forms of feldspar; the former being decomposed and of a clay-like texture, the latter crystalline. They consist mainly of silex and alumina, which, when partially fused, form a glass that cements the unfused particles and gives translucency to the whole. The decomposition of the kaolin is, perhaps, owing to a crystallization established at considerable depths and high temperatures. The conditions of expansion and tension being consequently different from those usually observed, the whole mass was subjected to an abnormal strain, somewhat like that of the Prince Rupert's drops. When, by subsequent convulsions, the primitive metamorphic rocks were lifted to the surface, the change of conditions favored disintegration and a readjustment of particles, which might lead either to new crystallizations, or, if the moisture was sufficient, to the formation of clayey beds.



The Japanese appear to have established porcelain factories at or about the mezzo-majolica period. Borrowing their methods and processes from the Chinese, their quickness of perception made them good imitators, both of art and of nature. Hence a comparison of their early wares, with the Chinese wares of the same date, shows the difference between naturalism and conventionalism, between life and death, between originality and imitation, between idealism and traditionalism. The works at Hizen, Kaga, Kioto, Satsuma, and

Yeraku were represented at the Centennial by samples of Some-Tsuki, or blue ware painted with cobalt oxide under the glaze; Kanyu, Hibiki or "Craquelé"; Seidji, or Seladon; Akai, or red ware; and Gosai, or Nishikide, painted with vitrifiable colors upon the glaze. The Kanyu was curious, but very little of it had any artistic merit.

The cracks with which the surface is covered, are due to differences in the rate with which the glaze and body of the ware contract in cooling, a difference which was at first accidental, and afterwards intentionally imitated, by selecting ingredients which would uniformly produce similar results, and gratify the taste of the merely curious. Some of the Satsuma "craquelé," however, was so fine as to produce a peculiarly pleasing crape-like effect, as you may see by the jug on the table.

The first manufactory of European porcelain was erected by Augustus II, at Meissen, on the Elbe, about A. D. 1698. He had employed John Frederick Böttcher, a reputed alchemist, to conduct researches for his benefit. In the preparation of crucibles that would stand an intense heat, Böttcher found a clay that made a fine red ware, similar to the Japanese Akai. Noticing, one morning, that his wig was very heavy, he found that his valet had used a new hair-powder, which had been introduced by a wealthy iron-master, whose horse's feet had one day stuck fast in a bed of white mud. The mud, when dry, yielded a fine powder, which made a cheap substitute for the wheat flour, then used for hair-powder. Böttcher found, upon analysis, that this was precisely what was needed for making the finest white porcelain. The workmen were sworn to secrecy, but the process gradually leaking out, factories were established at Berlin, Vienna, Höchst, Naples and Sèvres.

In England, A. D. 1710, two brothers, by the name of Elers, from Nürnberg, made a fine pottery, by a secret process, at Burslem, in Staffordshire. A potter, by the name of Astbury, counterfeiting idiocy, learned the art, and drove out the Elerses by his competition. Works had been previously established in Fulham, Chelsea, and Bow. About 1760, Josiah Wedgwood began imitating agate and tortoise shell in the manufacture of porcelain knife-handles and various ornamental articles. He sent a service of cream-colored ware to Queen Charlotte, who was so much pleased with it that he

called the ware, at her request, "Queen's Ware." Wedgwood's copies of the Portland Vase and other antiques, together with his original productions, which were embellished by Flaxman, soon gave him a world-wide and lasting fame. His reputation stimulated others, and successful works were established at Derby, Plymouth, Bristol, Worcester and Lowestoft. The wares of Minton and Copeland compare favorably with those of Dresden and Berlin, both in quality and in ornamental decoration. The Lambeth Faience, or Doulton ware, which deservedly attracted so much attention at the Centennial, is a reproduction of the "Grès Cérame," or "Grès de Flandres," resembling some of the earliest known Chinese stoneware. The raised decorations are made by pressing clay into moulds, as in the old Samian ware of Greece. By combining the ornaments in relief with indentations of bold lines and patterns, engravings by incised lines, and surface painting or printing, all necessity for duplication is avoided, and various artistic articles of daily use are produced at a moderate cost.

If this rapid survey of the ceramic art has recalled to your minds any features of the Exhibition, which you might otherwise have forgotten, if it has helped towards satisfying your curiosity upon any points, or if it has shown you that the Centennial was a school of even more abundant teaching than you had imagined, my object has been accomplished. In these three lectures, I have directed your attention only to a few of the most obvious lessons, but I trust they have sufficed to show you the importance of mutual helpfulness, among nations as well as among individuals; the advantages of high ideals towards which artisans and artists alike may work; the superiority of the spiritual over the physical nature of man; the inheritance of common aspirations and common destinies, which is never more manifest than in International Exhibitions, where "one touch of nature makes the whole world kin."

[The illustrations, in this report, were loaned by Messrs. Galloway & Graff, 1725 Market street. The vases are all copies of antique designs.]